In Two Sections

Electrical Engineering

July
1931

Section
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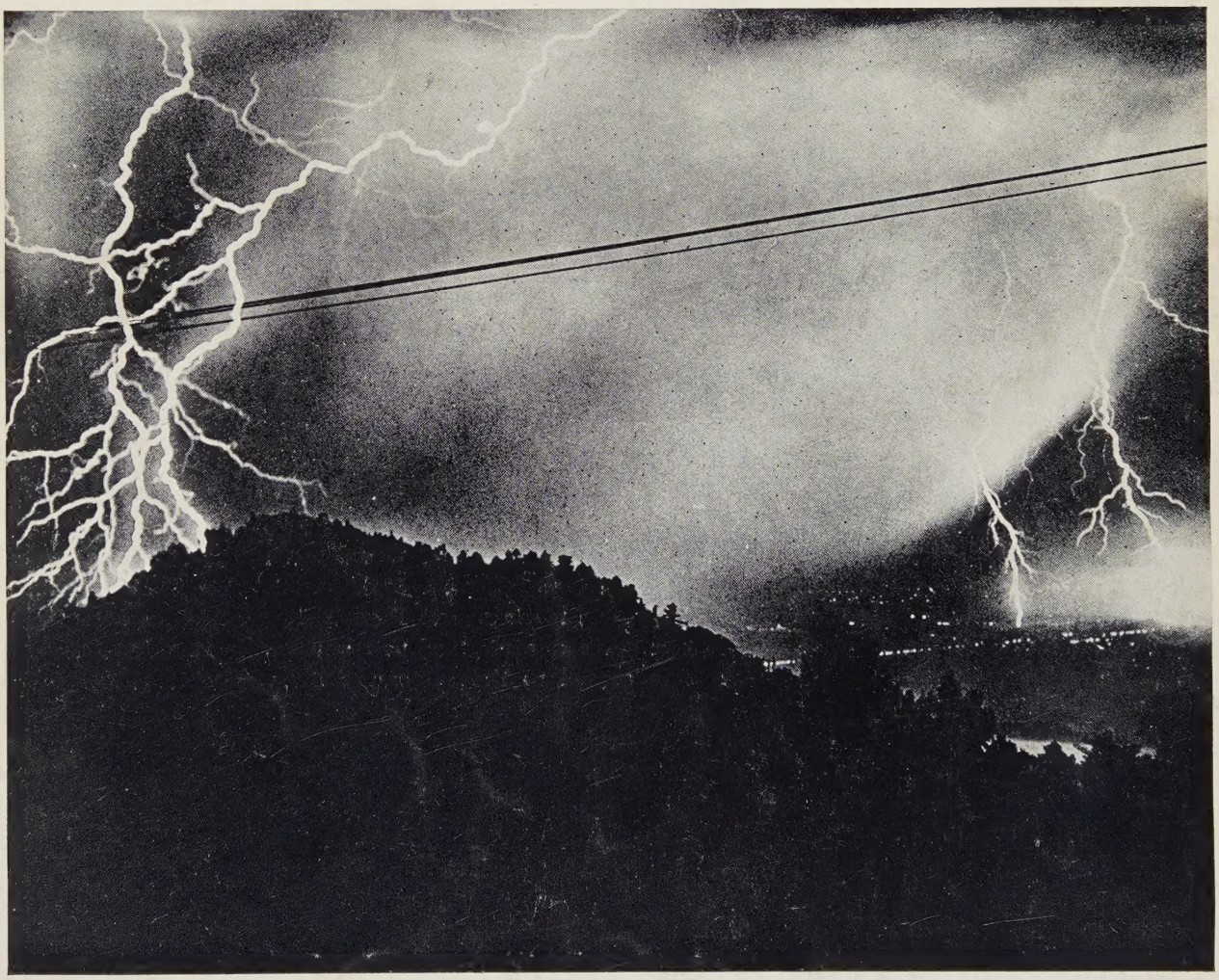

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FUTURE MEETINGS

of the

American Institute of Electrical Engineers

Place	*Dates*	*Nature*	*Latest Date for Receipt of Manuscripts*
Lake Tahoe, Calif.	Aug. 25-28, 1931	Pacific Coast Convention	(Closed)
Kansas City, Mo.	Oct. 22-24, 1931	District Meeting	July 22, 1931
New York, N. Y.	Jan. 25-29, 1932	Winter Convention	Oct. 26, 1931
Milwaukee, Wis.	March 14-16, 1932	District Meeting	Dec. 14, 1931
Providence, R. I.	May - 1932	District Meeting	Feb. - 1932

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that their papers may be docketed for consideration by the Meetings and Papers Committee, as programs for all meetings are formulated several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author information in regard to the Institute's rules relating to the preparation of manuscript and illustrations.

MEETINGS OF OTHER SOCIETIES

CAMP COOPERATION XI—Association Island, Henderson Harbor, New York (Society for Electrical Development, 420 Lexington Avenue, New York City) July 27-31.

ROCKY MOUNTAIN DIVISION N. E. L. A., annual convention, Stanley Hotel, Estes Park, Colo., September 2-4, 1931.

ILLUMINATING ENGINEERING SOCIETY, annual convention, Pittsburgh, Pa., October 13-16, 1931.

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THE LIGHTNING SEASON being at hand, it is pertinent that serious attention be given to the effects of this phenomenon upon electric power transmission. Much has been accomplished by the Institute's lightning subcommittee since its appointment in 1926; the work has been greatly expedited within the past two years by the use of several new instruments, and by the concentration of effort upon a few systems. Important results of recent investigations, contained in twelve Institute papers, have been abstracted and correlated in six articles. (*See pages 478 to 502.*)

PACIFIC COAST convention with its excellent technical program embracing subjects from cathode drops to industrial applications, and its delightful admixture of recreational and entertainment features, offers first-class vacation possibilities. Why not take advantage of the special convention rates available at Tahoe Tavern for the entire convention week? (*See page 514.*)

ANNUAL MEETING of the Institute comprised the opening session of the summer convention; results of the recent election of officers, and the annual report of the board of directors, were among the important matters receiving attention. (*See page 522.*)

DR. W. J. FOSTER (F'16) recently awarded the Lamme Medal, was presented the trophy with appropriate ceremony during the summer convention. (*See page 519.*)

"FOR THE PURPOSE of studying the present and any proposed future activities of the Institute," the new Institute policy committee was appointed at the May 19 meeting of the board of directors. (*See page 523.*)

H. B. SMITH (F'13) past-president of the Institute, has resigned his post at Worcester Polytechnic Institute, and plans to resume professional practise. (*See page 524.*)

W. S. LEE (F'13) sagacious president of the Institute, in his summer convention address interprets the spirit of modern engineering in one word—*coordination*—and indicates therein a fruitful field of endeavor for the young engineer. (*See page 512.*)

STEEL MILL engineers especially may be interested in the development of twin-motor drive for heavy rolling mills. (*See page 506.*)

SUMMER CONVENTION news will be especially interesting to those unable to attend and participate in its varied technical and recreational program. (*See page 517.*)

OVERSEAS TELEPHONE service by radio first was introduced more than four years ago and now is accepted as quite the ordinary thing. Recent developments are described by F. A. Cowan (M'29). (*See page 476.*)

Relay Protection for A "Close-Linked" System

Relay-protection design involves a detailed study not only of the required standards of service but also of the general design and layout of the power system to be protected. The "close-linked" type of system of Chicago and the special relaying system which it demanded, are discussed.

By
T. G. LeCLAIR
Member A. I. E. E.

Commonwealth Edison Co., Chicago, Ill.

SERVICE RELIABILITY required of electric power systems today is accomplished fundamentally by two general means. One might be termed "preventive engineering" and the other "protective engineering." The former presupposes a system and its related equipment designed and built to a degree of perfection that makes failure impossible while the latter aims to minimize and localize such troubles as may occur.

Obviously, *complete* prevention of failure is impossible of practical attainment; hence protection against line and apparatus failure becomes a necessity. Theoretically a fault is not considered serious provided the capacity and extent of equipment involved is small and that the protective equipment will operate to isolate the trouble quickly. From a power-system standpoint, therefore, protective devices are installed to protect the system as a whole, rather than individual lines or equipment, against the disturbing effects of faults.

General System Design

Of first importance in the matter of power-system protection is the question of the general system design; and so far as the larger cities of the United States are concerned, this may be classified into three principal types as follow:

1. "Loose-linked" system of Detroit.

Each group of distribution circuits is provided with a substation and for each group of substations there is a generating station of sufficient normal capacity to care for the group of substations operating from its buses. The loose-linking characteristic is found in interconnection of areas which are served by different generating stations with tie cables so designed as to have relatively low capacity compared to the total load emanating from a generating station, but of sufficient capacity to serve normal and emergency power interchange between different load districts. Thus, the different load areas are all linked together for normal service, but each is subject to quick and complete isolation from its neighbors, minimizing the possibility of any system-wide disturbance which might result from a serious fault in any load district. (See A. I. E. E. Trans., Vol. 48, Oct. 1929, pp. 1080-2.)

2. "Synchronized-at-the-load" system of New York.

All supply cables are short; generating stations are close to the load and all are of closely similar efficiency. Transmission and tie-lines are so arranged that any station may feed to any or all load centers. Thus the loss of any one source will not interrupt service at the load; power is widely available under emergency conditions and yet relatively low short-circuit currents arise, a factor of prime importance. (See A. I. E. E. Trans., Vol. 48, Oct. 1929, pp. 1080-2.)

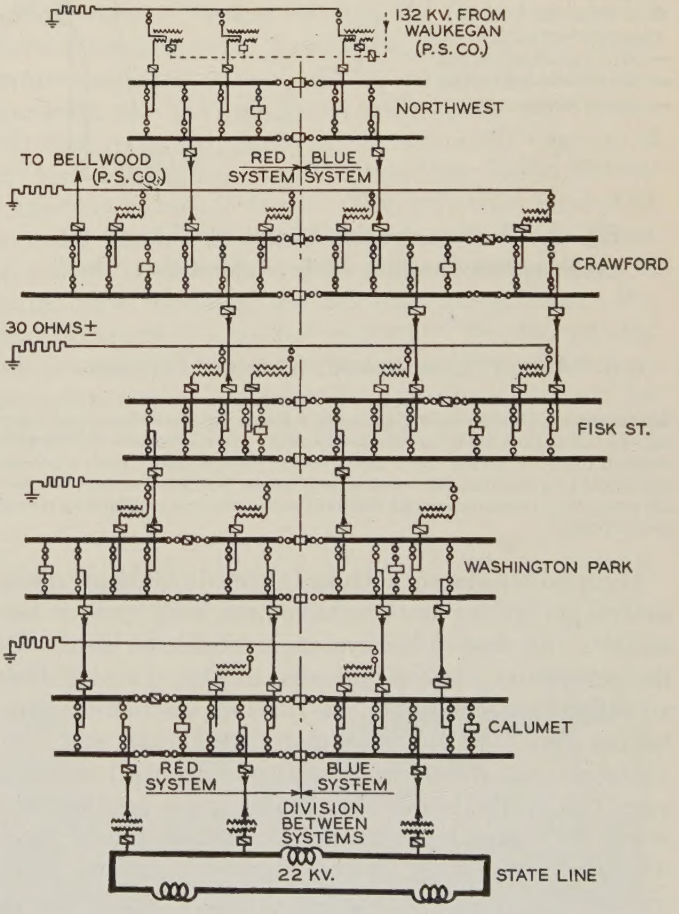


Fig. 1. Schematic diagram of Chicago "close-linked" transmission system. Note especially that system is normally divided into two distinct parts ("red" and "blue"); also that generating stations are connected by 66-kv. low-reactance tie cables

From a talk presented informally at a joint meeting of the Chicago Section of the A. I. E. E., and the Western Society of Engineers, held in Chicago, Oct. 23, 1930. Not published in pamphlet form.

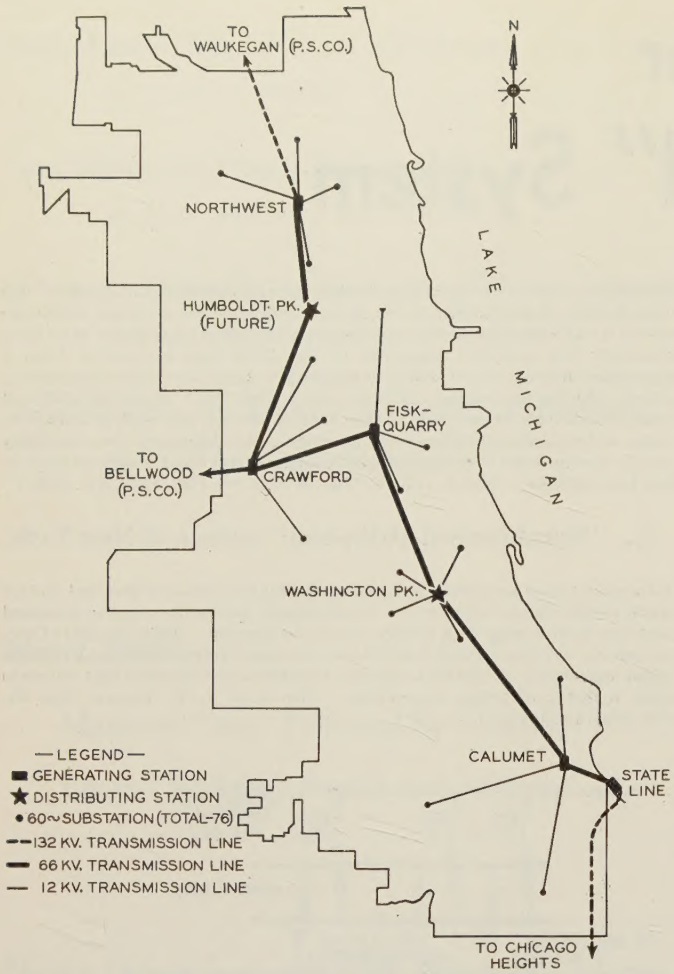


Fig. 2. Semi-geographic layout of Chicago 60-cycle system showing 66-kv. inter-station "bus"

3. Bus or "close-linked" system of Chicago.

This system is illustrated in Figs. 1 and 2 where various independent loads may be noted, each fed from separate sources. All sources are tied together through reactors, permitting a direct energy interchange. Such a scheme has certain limitations, the most serious being that short-circuit currents are large, thus requiring special means of accomplishing satisfactory circuit interruption.

For a power system such as the one in Chicago where several generating stations have been built more or less as units, the close-linked system is considered ideal. Of the generating stations indicated in Figs. 1 and 2, Fisk and Quarry stations are "old-timers," the newest units having been installed more than fifteen years ago. At Crawford station the oldest unit was installed some six years ago, while the oldest at State Line is less than two years old. Because operating efficiencies among these stations vary greatly, it is necessary to provide for a transfer of load between different sources in order to realize the best over-all operating economy.

This load transfer is accomplished through a 66-kv. "inter-station" bus which stretches the entire length of the city as may be seen in Fig. 2. All six steam-electric generating stations representing the aggregate installed capacity of 1,298,000 kw. are interconnected by

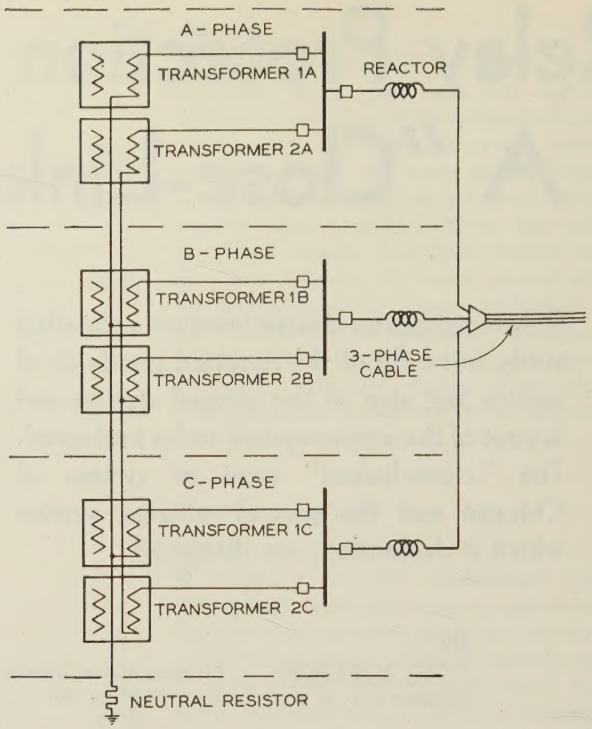


Fig. 3. Illustrating isolated-phase grouping of two transformer banks

means of this 66-kv. transmission bus. Electrically these station interconnections are extremely short, their reactance being so low that with maximum load the total voltage variation from one end of the city to the other does not exceed three or four per cent.

With this system it is possible to tap off at any given station the load needed for that particular local territory the transformer capacity of the station in question being governed of course by the load to be served. However, there are certain difficulties involved because with this close-linked system any one fault member will involve the entire system. For this reason the system has been split throughout into two parts. The 66 kv. buses of the two parts are capable of interconnection in the various stations but only in rare cases are they actually operated tied together. Thus, there are practically two duplicate systems; and trouble on one of them will not interfere with the other. For purposes of clarity some of the illustrations refer to these two parts as "red" and "blue" systems.

Isolated-Phase Construction

Short-circuit current which would arise if the two systems were operated tied together would be practically impossible to handle with the existing circuit-interrupting equipment and conventional group-phase construction. Even with the systems separated, the problem of handling the interruption of fault current is a serious one. An expedient which has done more than any other single thing to make practicable the opera-

tion of such a system is the isolated-phase construction. With this type of construction it is possible to throw the entire station capacity upon one bus, where emergencies require, yet the short-circuit current is low enough so that an ordinary circuit breaker can interrupt it satisfactorily.

A diagrammatic presentation of this isolated-phase arrangement is given in Fig. 3 where two transformer banks are shown so connected that both the phase unit of the bank itself and the phase leads from the bank are widely separated physically from those of adjacent phases. The leads are not brought close together until they have passed through suitable reactance capable of limiting the short-circuit current to an easily interruptable value.

Most important among the features of the isolated-phase system is the relatively-high resistance or reactance employed in the neutral connection. Normally, in a star-connected system all loads are carefully balanced between phases and practically no current flows through the neutral; on the other hand in the isolated-phase system, practically all fault current will flow through the neutral since phase-to-phase faults are almost impossible on account of the great physical separation between exposed parts. This greatly simplifies the protection problem without interfering in any way with the system regulation.

With the isolated-phase construction of a 66-kv. outdoor terminal not only are the phase leads separated by a distance of 30 ft. or more, but by a metal screen of generous proportions as well. (See Fig. 4.) In indoor generating station construction whether for 12 kv. or 66 kv. each phase is housed in a separate room or on a separate floor. This type of construction is used also for the newer and larger substations; in the older and smaller substations the arrangement of lines and buses is depended upon to prevent complete shut-downs. No two lines to a substation group originate on the same line bus but are divided among the different sections of the generating station main bus.

Fault Bus for Protecting Switching Equipment

As mentioned in the beginning of this article, protective equipment must be installed to guard against the disturbing effect of those failures which system design cannot prevent. To be ideal, of course, protective devices must disconnect faulty equipment only, and in addition operate instantaneously; this ideal is achieved or approached wherever economically justifiable.

Practically instantaneous clearing of faults can be secured by employing the fault bus, a device for system protection which is of maximum benefit with isolated-phase construction. It consists essentially of a separate bus isolated from ground but connected through a current transformer to the main ground bus. Each unit group of switching equipment has its own fault bus through which the oil switch tanks, insulator bases, and other equipment cases are grounded and to which flash plates are connected. These flash plates are so arranged that no flashover can occur without the resultant current flowing through the fault bus and its current transformer. A relay in this current transformer secondary circuit can be set for instantaneous operation and the unit group wherein the fault occurs will then be quickly isolated. A schematic diagram of the fault-bus connections in a generating station switchhouse may be seen in Fig. 5. Here two main buses with outgoing lines are connected to so-called line buses; all can be fed from either one of the main buses. The dotted lines represent the fault-bus connections. If a fault occurs on the line bus marked (x) the fault current will flow through the fault bus and current transformer and actuate relay 3 which will trip the four line switches and also the two group switches A and B, thereby

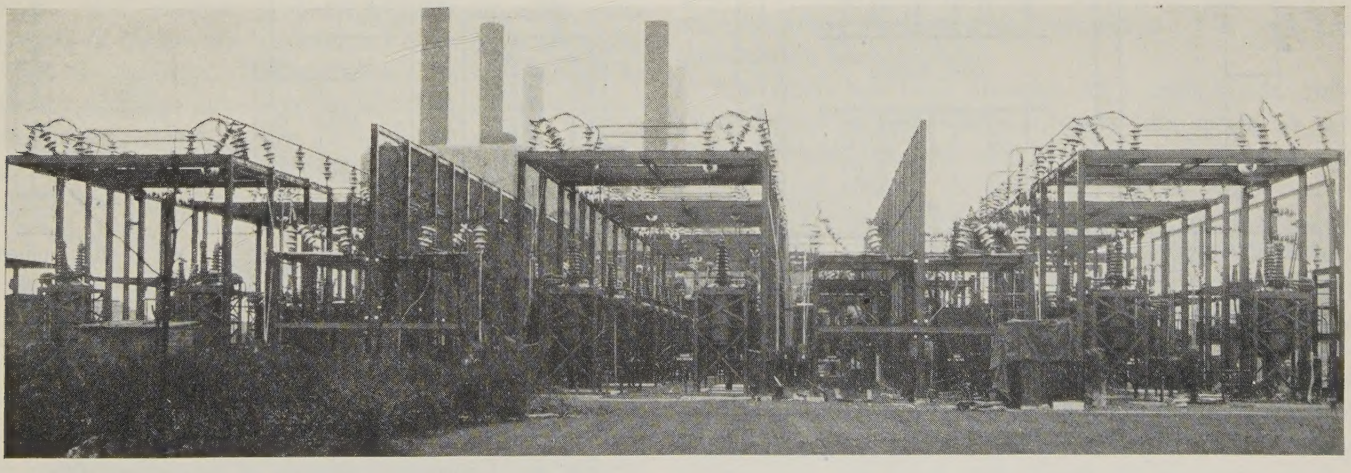


Fig. 4. Outdoor 66-kv. switching terminal at Calumet generating station. Note isolated-phase construction and high screen barriers between phase groups

isolating the fault. For faults between two unit groups, time sequence relaying is employed to prevent unnecessary switch-openings. For instance, if a fault occurs on switch *E*, relay 4 will first trip the line and group switches; and if the fault is not cleared within 0.7 sec., relay 7 will trip all switches connected to the red main bus section where switch *E* is connected.

Fault buses are now installed in all new generating stations, distribution stations, 66-kv. terminals and some of the larger substations to protect against bus and equipment failures.

Differential Relay Protection for Generators and Large Transformers

A differential method of relaying is employed to disconnect faulty generators and 66-kv. transformers from the system. For generator protection the simple conventional scheme with a sensitive relay is used. For three-winding transformers, however, this simple arrangement cannot be used, especially where one or two windings are equipped for tap changing under load. Further difficulties are encountered because of the 30-ohm neutral resistance in the 66-kv. system; consequently, one set of relays is connected differentially across all three windings. (See Fig. 6.) These relays are of the *percentage differential* type; that is, they will trip when the tripping current exceeds a predetermined percentage of the load current. (See "Percentage-Differential Transformer Protection," p. 361, May 1931 issue of Electrical Engineering.) On account of the tap-changers, this percentage for these relays must be relatively high, a value of 50 per cent being used. For faults on the 66-kv. winding close to the neutral, because of the neutral resistor limiting the fault current, a more sensitive relay is required. A second set of differential relays, connected across the 66-kv. winding, and with a setting as low as from 2.5 to 5.0 per cent, is therefore provided. In addition to the differential relays, ordinary overload relays are installed on the 12-kv. side of main and regulating transformers.

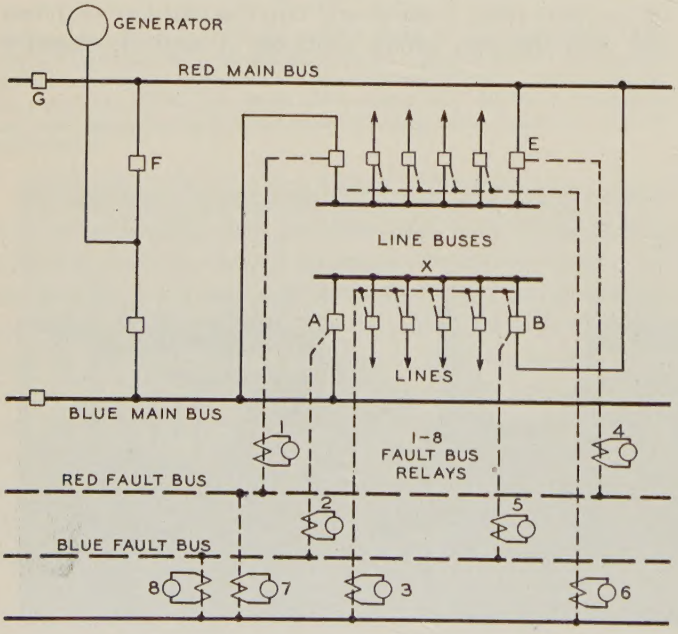


Fig. 5. Schematic diagram for typical section of fault bus

Pilot-Wire Relaying for Tie-Line Protection

As shown in Fig. 1 the 66-kv. tie lines between generating stations are connected to buses at the transmission terminals, these buses being divided into several sections and operated split or tied together depending upon the system requirements. The best way known to isolate instantaneously a faulty line on this type of system is the pilot-wire-relay scheme. This system, while rather costly, is justified by the size of the lines and the importance of the service. A three-phase scheme is employed with four pilot wires, pilot transformers, balancing resistors, and capacitors. It has been found that the capacitors can be omitted in the Chicago system, where the lines are all less than eleven miles long.

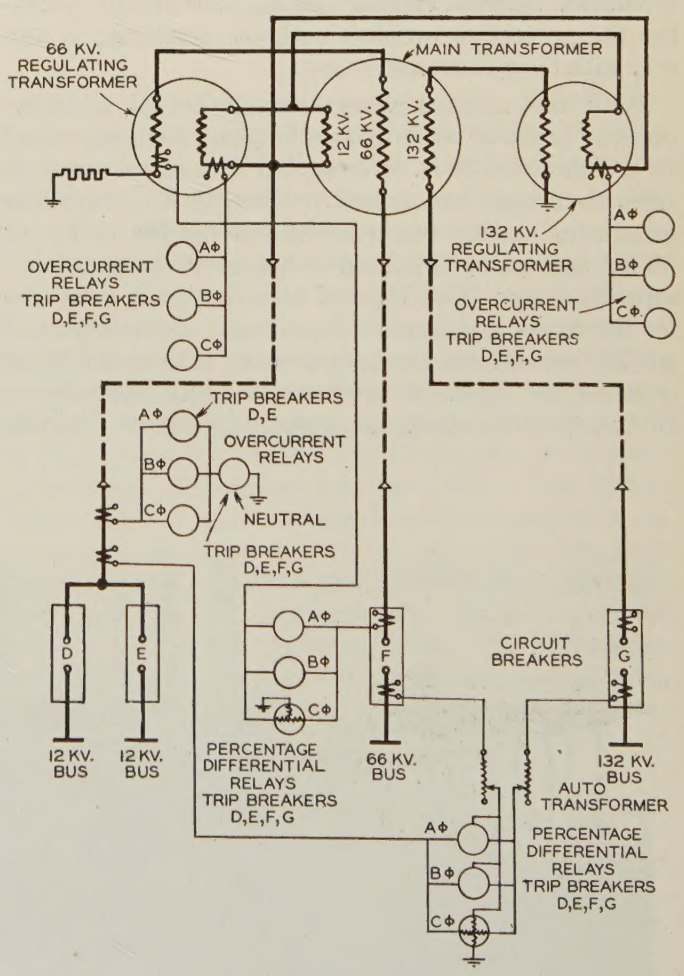


Fig. 6. Connection diagram of percentage-differential relays for protecting three-winding tap-changing transformers

Sectionalization

In addition to the usual protective schemes, there are in use on this system means for preventing the spread of trouble; these cannot be classed with protective devices. As previously mentioned, the 66-kv. system is divided into two parts which are normally operated as independent units, so that trouble on one-half cannot affect the other half, even should the protective devices fail. On the 12-kv. system, the stations also are separated into two or more parts for the purpose of preventing the spread of trouble. These two parts may be permanently separated through reactance, which will limit the flow of short-circuit current; or they may be operated normally tied together and automatically sectionalized by relays. Normally these sectionalizing relays will not interrupt any service but are intended to separate each section and its dependent lines into a number of self-sustained units. In this way, failure of protective devices on one of these units will not spread the trouble to the other units.

Substation and 12-Kv. Line Protection

The isolated-phase construction with fault-bus protection has been extended to some of the later and larger substations; in others, line relays are relied upon for the proper clearing of faulty buses. For line protection, ordinary overload directional and balanced differential relays are used.

Up to a few years ago, the systems so far touched upon would have been all that required consideration when planning reliable supply for a city like Chicago. Now, however, some of these stations are shut down part time and more efficient generating capacity outside of Chicago is depended upon for the supply. This energy is delivered over long overhead transmission lines and their protection becomes part of the problem of service security.

One great difficulty with overhead lines is their susceptibility to lightning—a problem not yet completely solved. Still another problem to consider when large amounts of power are transmitted over great distances is that of stability. Several means for increasing the stability of a line have been introduced, however, most common among which are, (1) increasing the speed of clearing faults; (2) providing high speed excitation; and (3) changing system connections.

Conclusion

Past progress toward the goal of perfectly reliable service has been along three principal paths; namely, (1) improving the individual units of equipment, (2) providing faster and more reliable isolating devices, and (3) designing the complete system so that the loss of individual parts may be tolerated. In the future the metropolitan system should make its greatest advances along the line of general system developments based upon the present high quality of equipment. Marked improvement in the reliability of long overhead lines with a high degree of exposure may be expected, particularly when the power delivered must meet the exacting standards of metropolitan service.

Magnetic "Iron" Perfected by Research

THIRTY years ago great quantities of iron were necessary in cores of electrical devices to prevent undue electrical loss. High temperatures caused magnetic deterioration of the metal. Even alloys of apparently constant chemical composition had varying magnetic properties. In view of this obstacle, progress in transformers of electrical currents was especially difficult.

Then came the first big improvement; Hadfield in England discovered silicon as an alloying element with iron. In 1903 silicon steel appeared there, and a little later here. This new steel cut losses in half. They were again cut in half by better mill practise and improved raw material. For the next decade further progress was slow, improvements small. Things had again reached an impasse.

About that time, an effort was made by the writer at the University of Illinois to make iron alloys of only the purest materials obtainable. For nearly sixteen years the research has continued; one of its main objects being to determine the properties of really pure iron, because iron is the basis of all important magnetic materials. Who would have believed that the elimination of a few thousandths of one per cent of carbon could be responsible for raising the maximum permeability of iron from perhaps 10,000 to 50,000 with corresponding decreases in hysteresis? Yet this has been amply demonstrated.

The work has been fraught with exceptional difficulties since it dealt with subjects like strain in the crystal structures, and with impurities in thousandths of one per cent. Furthermore, these very small amounts of oxygen, carbon, and sulphur exist in solution in solid iron—like sugar in solution in a glass of water.

Commercially, the most important results have come from the study of iron-silicon and iron-nickel alloys. Laboratory results are not rapidly translated into commercial practise. Five years after the first published results, no appreciable effect appeared in commercial steel. In 1920, after much discussion and many experiments, the steel mills began to put some of the

From an article written by Dr. T. D. Yensen of the Westinghouse Research Laboratories for *Research Narratives*, Feb. 15, 1931, published by the Engineering Foundation, Inc., 29 West 39th Street, New York, N. Y.

findings into practise and there has since been a steady annual improvement in the quality of electrical sheet iron. Now the commercial material is almost as good as the laboratory product of a few years ago.

Hipernik (an alloy of half iron and half nickel) is another product of the laboratory. At first used in high-quality radio receiving sets where it contributed largely to the elimination of distortion of sounds in reproduction, it has gradually entered other important fields. In the near future we may find this alloy in many places where iron-silicon alloys are used today. Here again the difference between the ordinary alloy and hipernik cannot be ascertained by usual chemical analysis; radically new methods had to be devised.

(EDITOR'S NOTE: Under date of May 25, 1931, the American Rolling Mill Company, Middletown, Ohio, announced that this special alloy now is being rolled commercially from 6-ton ingots.)

Associates who have contributed to this success include G. H. Cole,[1] A. A. Frey, T. Spooner[2] and N. A. Ziegler. In its large practical results, this long and painstaking research is a vivid example of how the affairs of men are affected by scientific work which only a few years ago would have appeared hopelessly theoretical.

Overseas Radio Telephone Service

More than four years have elapsed since the installation of the first transoceanic radio-telephone circuit between New York and London. Some of the more recent developments in this class of service are discussed here.

By
F. A. COWAN
Member A. I. E. E.

American Tel. & Tel. Co., New York, N. Y.

SHORT-WAVE RADIO has played an important part in the extension of the telephone frontiers beyond the boundaries of this North American continent. During the four years which have elapsed since the first commercial telephone service between this country and Europe was inaugurated all of the world's overseas telephone extensions have employed short-wave radio. With the exception of the original New York-London circuit which operates on 1,500 m., the wavelengths used have ranged between 14 and 100 m. Today there are three short-wave circuits between New York and London supplementing the original long-wave circuit. In addition to these there is a circuit between New York and Buenos Aires, Argentina, circuits from New York to ships at sea, and one from London to Sidney, Australia (See Fig. 1). All of these circuits are available to telephone users in this country, and in addition to these facilities, extensions are being planned between New York and Hamilton, Bermuda, New York and Rio de Janeiro, and San Francisco and Honolulu, Hawaii. Since such factors as susceptibility to noise in transmission across equatorial regions, and the character of other transmission variables, including economic considerations, favor the use of short *vs.* long waves, all of these circuits will employ short-wave radio.

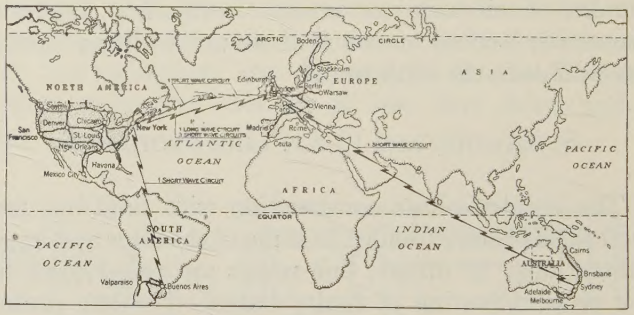


Fig. 1. Radio links between telephone systems of North America and other countries

NEW YORK-BUENOS AIRES CIRCUIT

A schematic layout of the New York-Buenos Aires circuit may be seen in Fig. 2. A crystal-controlled high-powered transmitter employing water-cooled vacuum tubes with an output of between 15 and 20 kw. is employed at both terminals. Associated with this transmitter are directive antennas which increase the signal strength by an amount equivalent to a 20- to 50-fold increase in transmitted power. Upon leaving the transmitting station, signals travel by the well-known sky-wave route to the foreign terminal. Radio receiving stations of the double-detection type equipped with automatic gain control and directive antennas are employed. To care for the changing transmission conditions these directive antennas are provided for three separate wavelengths. The received speech signals are transmitted from the receiving station to the foreign subscriber over land lines.

These directive-antenna arrays improve the receiving conditions by strengthening the signal received from the selected direction, reducing the effect of noise and other

From "Recent Developments in the Operation of Radio Telephone Service," (No. 31-57) presented at the A. I. E. E. Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

1. Member '27. 2. Fellow '29.

signals coming from other directions. The automatic gain-control feature compensates for moment-to-moment variations in the strength of the received carrier wave and when radio noise conditions are satisfactory the complete receiving system is capable of satisfactorily utilizing a signal having a field strength as low as one microvolt per meter. This performance has been made possible by the selection of a receiving site sufficiently isolated to minimize local interference,

Lost Circuit Time Analyzed

A comparative analysis of the lost circuit time for a typical summer month on the New York-Buenos Aires circuit and one of the New York-London short-wave circuits, is shown in Fig. 3. It may be noted in each case that the major percentage of lost time is due to atmospheric conditions.

Whereas normally the conditions are good, there are

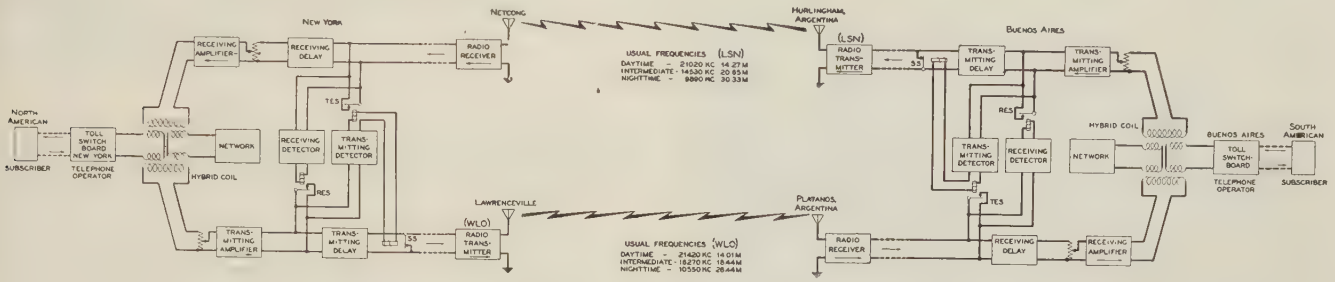


Fig. 2. Schematic layout of New York-Buenos Aires radio-telephone circuit

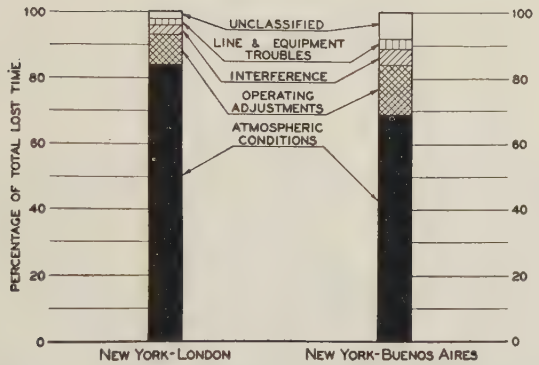


Fig. 3. Analysis of time lost on two short-wave radio-telephone circuits for a typical summer month

and by the careful design of the component parts of the receiving system.

At the terminal points voice-operated-relay switching equipment disables the radio path in one direction while speech is traveling in the opposite direction. It also maintains the transmitting side of the circuit in a disabled condition when no speech is being transmitted. This automatic switching simplifies the transmission problem by resolving the two-way circuit into two one-way circuits. The switching-relay circuits are carefully adjusted to compensate for any changing transmission conditions, thus minimizing interruptions due to false operation of the relays.

Once the circuits of the type under consideration have been established their performance is controlled largely by the condition of the transmitting medium at any particular time. Since the control of this medium is beyond the scope of human endeavor, the operating problem becomes one of maintaining the component parts of the system in good condition and operating the system as a whole to best advantage.

times when, due to some disturbances of a nature not clearly understood, radio transmission from certain paths is seriously affected. These disturbances have been correlated reasonably well with abnormal activity in the magnetic field of the earth and are commonly known as "magnetic storms."

These occur at irregular intervals and at times result in reducing the signal strength at the receiving points to unusable values. Transmission on all frequencies is affected to a greater or lesser degree, and the time in each 24-hr. period during which reliable transmission can be expected is materially reduced. This interference usually is seriously effective for several days preceding and following the day on which the storm is actually at its height.

The equipment used in the short-wave radio circuits is so designed and constructed as to minimize the likelihood of trouble. In addition, spare units of equipment have been provided for replacing equipment which would be most subject to trouble or which would require considerable time to repair. These precautions, together with a systematic testing routine, account for the small amount of lost time due to equipment troubles.

In view of their adaptability to transmission over great distances and the rapid progress that is being made in improving, simplifying, and reducing their cost, short-wave radio systems are of outstanding importance in the development of world-wide telephonic communication. What the future will bring can only be guessed; but it does seem reasonably certain that for the next few years the short-wave circuits will continue to occupy a prominent position in the forward march toward the development of a world-wide telephone service.

That the concerted efforts of power companies and electrical manufacturers to combat the disturbing influences of lightning already have borne fruit, is attested by the greatly reduced transmission line outages from this cause. Results of recent investigations in this field as described in twelve Institute papers form the basis for the six articles which follow.

Theoretical Studies Laboratory and Field Tests Operating Experiences Lead to Effective System Protection Against

THE LIGHTNING PROBLEM as it affects the operation of electric light and power systems, according to Sporn logically divides itself into three parts:

1. Theoretical and laboratory investigations which include mathematical studies and various analyses of lightning phenomena.

2. Field research with natural and artificial lightning, which studies are enhanced from year to year by developments and improvements in equipment.

3. Evaluation of the effects of different devices and of line design upon the mitigation of lightning disturbances by the study and analysis of practical operating records.

This and the five articles following in this issue of ELECTRICAL ENGINEERING present a collection of theories and facts relating to these different aspects of the lightning problem. These articles have been prepared from twelve Institute papers (see Table I) of which three treat mainly the theories involved in lightning studies; two deal entirely with field investigations of surges imposed on transmission systems by means of artificial lightning discharges; four present the results of field investigations of natural lightning discharges; one gives the results of analysis and interpretation of a large quantity of operating data collected on systems in service; while one is devoted to a description of a new device designed to protect line insulators against flashovers.

An attempt has been made to correlate information from these different sources, outlining in some detail the most recent findings in this important field, and indicating the relation between these latest disclosures and previously accepted ideas. Additional information has been obtained quite recently regarding the mechanism of lightning formation and discharge, and some new theories have been advanced. It is realized generally, however, that present ideas still are entirely inadequate for a thorough understanding of the fundamental nature of lightning. Nevertheless, in spite of the obscurities, several important disclosures have been made. These are outlined in the paragraphs that follow and are based upon the results given in the entire set of twelve papers.

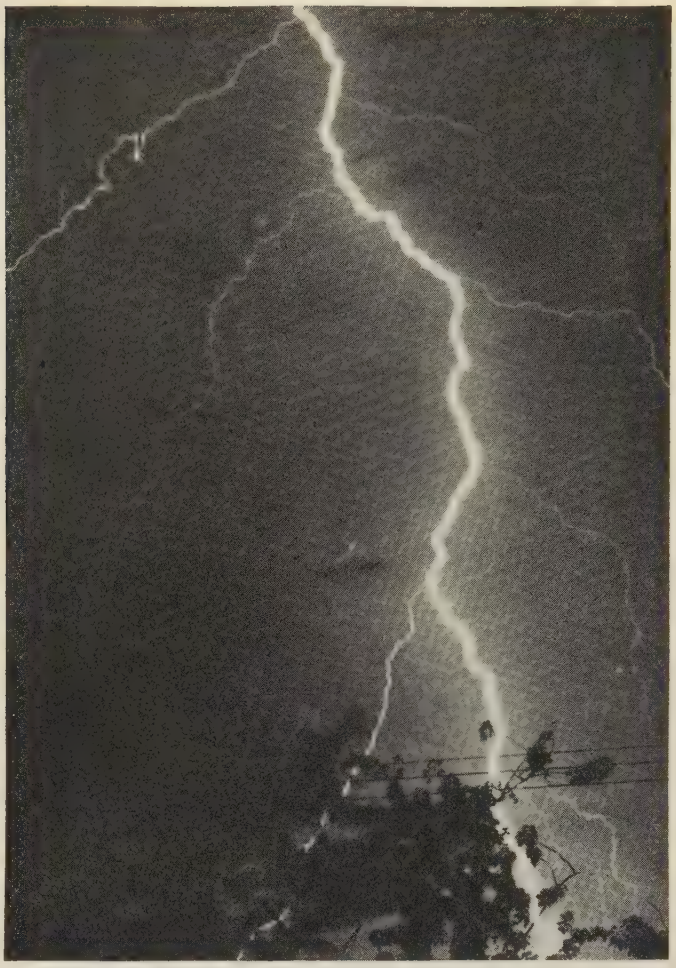
Concerted action in theoretical and field studies of natural and artificial lightning phenomena received its first great impetus in 1926 with the appointment of the lightning subcommittee of the A. I. E. E. transmission and distribution committee. This subcommittee was established primarily to assemble more definite information regarding the nature and characteristics of lightning and related electric system disturbances; also to ascertain possible protective measures with which to combat the troublesome disturbances. A general pooling of efforts and equipment followed, various utilities and the principal equipment manufacturers cooperating in practically all of the investigations subsequently carried out.

A paucity of suitable instruments hindered early work, the well-known klydonograph being practically the only instrument available. With that instrument it was possible to ascertain some idea as to the magnitude of lightning voltages, but the extremely short duration of such discharges made extremely difficult their accurate study with apparatus having mechanical recording elements. Development of new instruments and their liberal use, and the concentration of major field efforts upon a relatively few representative systems have been the two factors chiefly responsible for the rapid acceleration of lightning studies during 1929 and 1930.

DIRECT HITS AND INDUCED SURGES

Line surges can be very harmful whether due to direct hits or to induction from cloud discharges or strokes to nearby objects. It is generally recognized, however, that disturbances arising from direct strokes to line conductors or to ground wires on well grounded steel structures, subject lines to more severe punishment than do induced surges in general. The induced surge appears to be of minor importance on lines as highly insulated as are the 220-kv. lines in eastern Pennsylvania and New Jersey. Of course, voltages also can be induced on the conductors when a direct hit on the tower or ground wire occurs. Whether or not these induced voltages will cause a flashover appears to depend upon line insulation and tower footing resistance.

Lightning Disturbances



Westinghouse E. & M. Co. Photo

Wave Shapes

Wave shapes of lightning surges depend upon many varying factors, chief among which are the origin of the surge (whether induced or due to a direct stroke), duration of cloud discharge, and cloud height. Some of the many cathode-ray oscillograms which have been taken both of induced surges and direct strokes are reproduced in this symposium. Wave fronts varying in length from 2 to 9 microsec. with length of tail to half-voltage of from 6 to 40 microsec. have been observed. The total lengths of these waves vary from 10 to 160 microsec. In an oscillogram of a direct stroke estimated as terminating on the line 125 ft. from the laboratory, a voltage rise of 1,540 kv. per microsec. was recorded (see Fig. 16). Most of the oscillograms, however, were obtained at some distance from the point of incidence and, therefore, do not show the true wave shape at that point, having suffered distortion in traveling along the line.

Negative surges have steeper fronts than do those of positive polarity. It has been estimated that the former may have fronts as short as 1 microsec. or less, while the probable minimum for the latter is approximately 5 microsec.

Attenuation, Distortion, and Reflection

Traveling waves arising from lightning discharges undergo a continuous change as they proceed along the line, the general tendency being a slowing down of the front, a flattening of the tail, and a general increase in total length. Corona appears to be the greatest cause of this phenomenon; hence it follows that the reduction in wave crest is more rapid above than below the critical corona voltage. Attenuation is more rapid for extremely high-voltage surges and according to indications may be as high as 1,000 kv. per mi. of travel.

Surges impressed upon three parallel conductors evidence a more rapid slowing down of front but lower rate of attenuation than do waves on a single conductor. Reflections from line sections of changing impedance and from terminal equipment also are factors in wave shape change; characteristics of these reflections can be predicted by means of "lattice" diagrams.

Crest Voltages and Currents

The maximum voltage recorded in any of the tests described was 5,000 kv., measured on a wood pole line at a point about 4 mi. from the point of incidence of a direct stroke (see Fig. 21). Indications are that the voltage of a direct stroke may be as high as from 10,000 to 15,000 kv. A maximum discharge current of 670,000 amperes was reported, determined by adding together the tower ground currents for the several towers affected. This method may be subject to some errors; its merits are a controversial matter. Other indications, however, also point to a maximum of several hundred thousand amperes.

Polarity

No definite conclusions have been drawn in regard to polarity, but it seems well established that both positive and negative cloud potentials exist. However, more di-

Table I—Identification Data Pertaining to Lightning Papers Abstracted in This Group of Articles

Authors names	Company affiliations	Pamphlet copy titles	Serial numbers	Presented at	Dates presented
Edgar Bell Associate A. I. E. E. **A. L. Price** Associate A. I. E. E.	Penn. Pwr. & Lt. Co., Hazleton, Pa. Penn. Pwr. & Lt. Co., Hazleton, Pa.	Lightning Investigation on the 220-Kv. System of the Penn. Pwr. & Lt. Co. (1930)	31-89	District meeting, Rochester, N. Y.	April 29–May 2, 1931
L. V. Bewley Associate A. I. E. E.	Gen. Elec. Co., Pittsfield, Mass.	Traveling Waves on Transmission Systems	31-4	Winter convention, New York	Jan. 26–30, 1931
Otto Brune Associate A. I. E. E. **J. R. Eaton** Associate A. I. E. E.	Gen. Elec. Co., Pittsfield, Mass. Consumers Pwr. Co., West Jackson, Mich.	Experimental Studies in the Propagation of Lightning Surges on Transmission Lines	31-85	District meeting, Rochester, N. Y.	April 29–May 2, 1931
J. C. Dowell Associate A. I. E. E.	Gen. Elec. Co., Pittsfield, Mass.	Attenuation and Successive Reflections of Traveling Waves	31-42	Winter convention, New York	Jan. 26–30, 1931
C. L. Fortescue Fellow A. I. E. E. **R. N. Conwell** Fellow A. I. E. E.	West. Elec. & Mfg. Co., Pittsburgh, Pa. Pub. Serv. Elec. & Gas Co., Newark, N. J.	Lightning Discharges and Line Protective Measures	31-82	District meeting, Rochester, N. Y.	April 29–May 2, 1931
I. W. Gross Associate A. I. E. E. **J. H. Cox** Associate A. I. E. E.	Am. Gas & Elec. Co., New York West. Elec. & Mfg. Co., E. Pittsburgh, Pa.	Lightning Investigation on the Appalachian Elec. Pwr. Co's. Transmission System	31-86	District meeting, Rochester, N. Y.	April 29–May 2, 1931
W. W. Lewis Member A. I. E. E. **C. M. Foust** Associate A. I. E. E.	Gen. Elec. Co., Schenectady, N. Y. Gen. Elec. Co., Schenectady, N. Y.	Lightning Investigation on Transmission Lines—II	31-87	District meeting, Rochester, N. Y.	April 29–May 2, 1931
F. W. Peek, Jr. Fellow A. I. E. E.	Gen. Elec. Co., Pittsfield, Mass.	Lightning, Characteristics — Induced Voltages—Direct Strokes—Coordination — Transmission Line Design	31-88	District meeting, Rochester, N. Y.	April 29–May 2, 1931
R. R. Pittman Associate A. I. E. E. **J. J. Torok** Associate A. I. E. E.	Ark. Pwr. & Lt. Co., Pine Bluff, Ark. West. Elec. & Mfg. Co., East Pittsburgh, Pa.	Lightning Investigation on a Wood Pole Transmission Line	31-10	Winter convention, New York	Jan. 26–30, 1931
Philip Sporn Fellow A. I. E. E.	Am. Gas & Elec. Co., New York	1929 Lightning Experience on the 132-Kv. Transmission Lines of the Am. Gas and Elec. Co.	31-20	Winter convention, New York	Jan. 26–30, 1931
Philip Sporn Fellow A. I. E. E. **W. L. Lloyd, Jr.** Member A. I. E. E.	Am. Gas & Elec. Co., New York Gen. Elec. Co., Pittsfield, Mass.	1930 Lightning Investigations on the Transmission System of the Am. Gas and Elec. Co.	31-79	District meeting, Rochester, N. Y.	April 29–May 2, 1931
J. J. Torok Associate A. I. E. E.	West. Elec. & Mfg. Co., E. Pittsburgh, Pa.	An Experimental Lightning Protector for Insulators	31-9	Winter convention, New York	Jan. 26–30, 1931

rect strokes of negative polarity have been recorded than those of positive polarity, while the majority of induced strokes appear to be positive. The question of polarity is important inasmuch as negative strokes have been observed to have steeper wave fronts, while positive polarity surges attenuate more rapidly.

Extent of System Affected

Flashovers have occurred in the majority of cases on only one phase, but usually involve corresponding insulator assemblies at two or more adjacent towers. Evidences of direct-stroke currents have been observed in as many as five or six towers. On highly insulated ungrounded lines, such as the wood pole line previously mentioned, traveling waves of dangerous magnitude may reach substation equipment and cause flashovers there, since such equipment in general is less highly insulated than the line equipment. Under these conditions, especially good lightning arrester equipment is required at the stations. On well-grounded steel tower lines where flashovers do not occur, severe electrical disturbance usually is limited to a few structures, and any surge propagated over the conductor will be of extremely low magnitude.

Flashovers and Trip-Outs

Flashovers from direct strokes may occur if (1) the stroke terminates on the line conductor; (2) the stroke terminates on a tower of high surge impedance, thus raising the tower potential with reference to the conductor; (3) the stroke terminates on the ground wire between towers and the potential is of sufficient magnitude to cause flashover at that point,

in which case flashover at an adjacent tower is certain to occur.

Experience has shown that direct strokes may occur at towers of low footing resistance without subsequent flashover. Whether or not a trip-out will result when flashovers occur depends upon whether the amplitude and polarity relations of line voltage and current are such as to permit the establishment of a power arc at the time of flashover. That flashovers can occur without causing line trip-outs is definitely shown by records of a lightning surge of 2,500 kv. which did not cause a trip-out but which most certainly did cause a flashover.

Induced surges also may cause insulator flashovers with resultant line trip-outs, especially when direct strokes occur to nearby objects. The likelihood of these surges reaching flashover value, however, is minimized by the installation of conventional overhead ground wires.

Effects of Grounding

Beneficial effects of overhead ground wires have been proved without doubt both by special investigations and operating experiences. Operating experiences have shown also that two ground wires are much more effective than one alone. The effectiveness of ground wire protection depends to some extent upon tower footing resistance; where this is high, special grounding cables or counterpoises can be used effectively to lower the surge impedance of the structures. Counterpoise cables are most effective when extended out radially from the tower foot, but in practical cases are restricted by right-of-way limitations to the two directions along the line. Operating experiences show, however, that flashovers do not always concentrate at towers having high footing resistance.

Line Design

General requirements for good lightning protection are low lines, short spans, low tower footing resistance, and overhead ground wires. The number and position of overhead ground wires will depend upon the conductor configuration and the number of circuits. Spacing between conductors and ground wires must be large in order to prevent flashovers at mid-span.

For effective protection against direct strokes the tower footing resistance should not be more than 4 or 5 ohms. Where this is impractical special overhead ground wire structures, known as diverters, may be installed if the economics of the situation permit.

Protective Devices

Lightning arresters are especially applicable at substations to protect terminal equipment against lightning damage. The principal qualification is that they be placed reasonably close to the equipment they are designed to protect. Arresters also are used on transmission lines where provision cannot be made economically for the installation of overhead ground wires.

In this connection field investigations have shown that arresters of the expulsion type will successfully interrupt dynamic current follow-up. A promising new device now under development consists of a hollow fiber tube with electrodes at either end, wherein the breakdown element is the air contained in the tube. Grading shields have not been found to decrease the number of line outages, but, when properly installed, they do minimize the damage to insulators, line hardware, and conductors, and reduce the amount of cascading required.

Theories of
Lightning Discharge and Traveling Waves

Recent theoretical findings concerning lightning and traveling waves are discussed in this article. When corroborated by field tests, these results furnish information from which a systematic scheme of protection can be established. "Direct-hit" wires above ordinary "sky wires" are suggested and discussed.

LIGHTNING may cause abnormal voltages on power transmission lines in either of two different ways—by direct stroke or by induction. Some understanding of the formation of these surges is necessary before a systematic scheme of protection can be evolved.

According to Fortescue and Conwell the thundercloud consists of small particles of water-vapor, each carrying a minute charge of electricity, free negative charges attaching themselves to the vapor particles. Since the mobility of the resulting charged moisture particles is very small the only way in which a discharge can take place is through ionization. This ionization process results in the formation of a lightning streamer.

Some streamers will never reach the earth because of an insufficient charge in the cloud. This would indicate that lightning disturbances resulting from streamers which do reach the earth will vary somewhat

in severity over a wide range, depending upon the amount of energy which the cloud is capable of discharging. The energy in the streamer itself is mainly potential energy until the earth or a structure is reached, when its potential energy is changed instantly into kinetic energy in the form of a current wave moving at the velocity of light into the earth or structure through the path pioneered by the streamer. Negative reflections pass up the same lightning channel, increasing the discharge current and also the gradient in the cloud. This in turn tends to extend more streamers throughout the cloud until the available

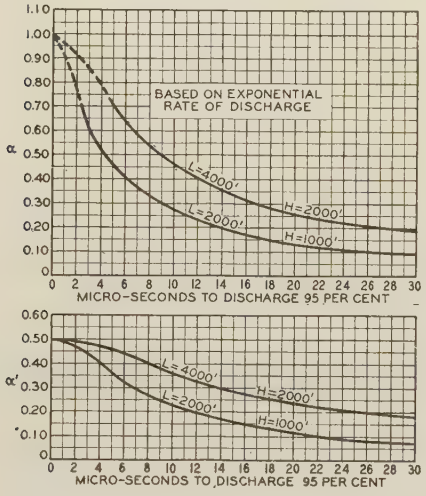


Fig. 1. Values of α for calculating lightning voltages induced on transmission lines (exponential rate of discharge assumed)

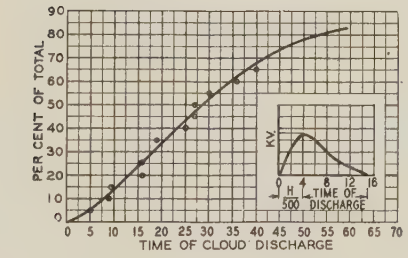


Fig. 2. Duration of cloud discharges determined from cathode-ray oscillograms

energy is decreased below the point necessary to maintain the lightning channel.

Complete data on the limiting value of lightning stroke potentials are not yet available but fairly good approximations for potentials ordinarily encountered may be made. Since voltages may be caused either by direct strokes or by induction, it is of practical importance to be able to estimate the numerical values of these voltages under both conditions.

Direct Strokes

Peek discusses the question of direct lightning strokes from the theoretical aspect and arrives at several interesting conclusions. The chance of a line being struck by a direct bolt increases of course with increasing height of line. On a flat plane without projections, a tower may be hit when the distance from it to the projection of the storm center is less than from four to ten times tower height. This factor is based upon the assumption that the nearest object will be hit and has been called the direct-hit ratio.

Where lines are brought through a right-of-way with nearby trees practically equal in height to the line, the hazard of direct strokes reaching the line should be very small. It has been found that a tree can direct or attract a lightning stroke as readily as can a metal tower because the charging takes place with low current and over a relatively long time. Also it has been found that the chance of any particular tower being struck does not depend upon its footing resistance, but that the resulting voltage on line insulators following a hit does depend almost entirely upon such resistance.

As a rule, a tower is more likely to be struck than the line. When this occurs the resulting voltage between line and tower, or ground wire, or across the line insulator string, is given by the formula

$$V_s = K I R$$

where K is a constant depending upon the tower and ground-wire configuration, I is the tower current (which will be less than the total-stroke current by the current flowing in the ground wire), and R represents the tower footing resistance. Fairly accurate approximations can be made by assuming $K = 0.8$. The importance of keeping the tower footing resistance low is obvious from the above formula if immunity from direct-stroke sparkovers is to be obtained.

As an example, it can be shown that on a line insulated with 14 disk insulator units, a tower resistance of 40 ohms would result in a voltage of 3,200 kv. on a 100,000-ampere direct bolt. In order to keep the voltage below sparkover value of this line the tower resistance must not exceed 20 ohms. For higher discharge currents the tower resistance must be correspondingly lower to prevent the establishment of sparkover voltages.

Induced Surges

When voltages occur by induction their polarity is opposite to that of the cloud source and their numerical values may be calculated by the formula

$$V = G h \alpha$$

where V is the voltage above ground, G is the potential gradient in volts per foot (100,000 is the accepted maximum value), h is the line height in feet, and α is a factor depending upon the duration of cloud discharge and the distribution of bound charge. Values of α calculated on the basis of an exponential rate of cloud discharge may be seen in Fig. 1. Since an instantaneous cloud discharge is impossible, α always will be less than unity. As plotted in Fig. 1 α is the factor to be used in computing maximum potentials at the point of origin while α' is the factor for computing the crest voltage on the resulting traveling wave.

That the distribution of bound charge affects the shape of the traveling wave to a much less extent than does the law of cloud discharge had been determined previously. The bound charge therefore can be assumed to be rectangular without involving any marked departure from the true shape of the traveling wave. Cathode-ray oscillograms are especially useful in determining the shape of traveling waves. If taken reasonably near the source and not badly distorted by sparkovers, losses, or reflections, they give practically the complete life history and characteristics of the stroke. In oscillograms of this nature the time from zero to crest voltage gives a measure of the length of bound charge, while the time from crest to zero on the falling part of the wave is the duration of cloud discharge. In addition the equivalent distance for one-half the time to crest approximates the height of the cloud. These ideas regarding the origin and characteristics of induced surges are concurred in by both Bewley and Peek.

Bewley points out, however, that as the time of cloud discharge increases, both α and α' (Fig. 1) decrease and rapidly approach equality for discharges slower than 10 microsec. He has computed also that for an average line height of 60 ft., and a 3,000-ft. rectangular bound charge (allowing 10 microsec. for the cloud discharge) the maximum voltage for induced traveling waves is somewhat less than 2,000 kv. A similar computation by Peek agrees with this value. It is evident that high-potential induced surges are possible only with very short waves and that for cloud discharges of long duration induced surges become quite harmless.

Peek, in discussing further the relations between traveling waves and cloud characteristics, states that information can best be obtained by cathode-ray oscillograph measurements made in the field. When the waves become distorted, however, the front no longer is of value in obtaining information on cloud height or length of bound charge because the values would be too high. The lengthened tails on such distorted waves indicate a longer duration than actually obtained. A good approximation, however, is that the duration of discharge is twice the time from crest to half voltage on the tail part of the wave. Since due to reflections a wave may persist for a number of loops, only the first loop is of interest for this approximation. Fig. 2 shows the results of a large number of such oscillograms where the crest voltages were higher than 100 kv. and line sparkover did not occur.

When the time and manner of discharge have been determined the lightning discharge current also can be ascertained mathematically. However, since these currents appear quite large (400,000 amperes for a typical case) confirmation by actual field measurements is necessary before final conclusions can be drawn.

General Properties of Traveling Waves

Bewley continues his theoretical study of traveling waves as outlined briefly in the following paragraphs.

The behavior of an n-conductor system having mutual inductance and capacitance between conductors can be formulated by a partial differential equation of the $2n$ order in both time and space derivatives. Although a formal solution for such an equation exists, it is too complicated to be of much use from an engineering point of view. However, solutions for (1) a no-loss system, (2) a completely transposed system, and (3) the steady-state alternating-current condition, are easily obtained.

If a line is free from losses the differential equations of the system are satisfied by pure wave functions. If the line is completely transposed so that every conductor occupies the same relative position as every other conductor, and for the same distance, then the possible average velocities between terminals are reduced to two in number. The conventional method of calculating the steady-state alternating-current behavior of a transmission line by using constants to neutral is a very special case, but is rigorous for a single-circuit, three-phase, completely transposed line.

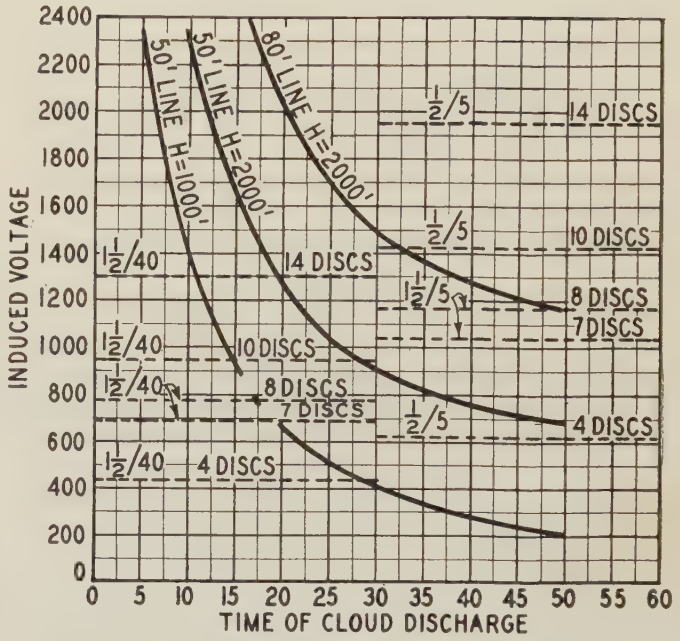


Fig. 3. Induced voltages on 50- and 80-ft. lines for different cloud-discharge durations and two cloud heights

For free traveling waves on a multi-conductor system, the energy is equally divided between the electrostatic and electromagnetic fields. However, when waves moving in the opposite direction pass through one another (as occurs from reflections at transition points) the energy balance is upset so that the energy resides more in one form than in the other. Pure traveling waves, which can occur only in a no-loss circuit, in general have as many possible velocities of propagation as there are conductors in the circuit. When the conductors are overhead wires these velocities all reduce to the velocity of light.

The behavior of traveling waves at general transition points (see Fig. 4) can be determined by a system of simultaneous equations involving the reflection, refraction, and transfer operators of the circuit. By a fortunate coincidence these can be expressed by one or the other of two equations containing only three parameters. In solving for different terminal conditions, therefore, it is necessary merely to tabulate the values of the three parameters for different cases with

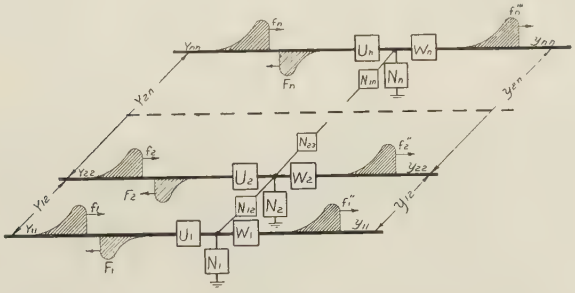


Fig. 4. Incident- and reflected-wave relations on a multi-conductor system

reference to the proper equation. Thus a large mass of information can be condensed into a relatively small space.

Typical Shapes of Traveling Waves

The principal shapes of most natural waves may be represented by the difference of two exponentials, the actual waves of course being serrated by minor irregularities. The cathode-ray oscillograph has proved its usefulness in investigating this phase of the problem, and during the past few years many oscillograms of natural lightning waves have been obtained under widely varying conditions. These have provided fairly definite information as to the general shape and characteristics of such surges. In calculating the effects of traveling waves, therefore, these characteristics must be kept in mind so that the influence of fronts, tails, and lengths of the waves may be evaluated. Three different methods for calculating waves of arbitrary shape are given by Bewley as follow:

1. Express in operational notation, combine with the function representing the reflection or refraction operator, and solve the resulting operational equations.

2. Consider the wave as made up of a series of infinite rectangular waves, adding the solutions corresponding to each component rectangular wave.

3. Express the wave as the sum of several functions for which the individual solutions are known or can be found, and add these solutions.

Each of these methods is subject to certain advantages and limitations. With the first method the operational equations usually are so complicated that a solution either cannot be obtained at all, or only by the most laborious and complex process. The second method is only an approximation, of course. In a great many cases, however, it is sufficiently accurate and has the advantage of simplicity especially where the incident wave is greatly complicated.

The third method, in which the wave is represented as a sum of functions for which the solutions are known, is quite useful and practicable. By properly compounding a few simple functions almost any desired wave shape can be reproduced with a fair degree of approximation. This process is illustrated for a few typical cases in Fig. 5 where the elementary waves considered are (1) infinite rectangular, (2) simple exponential, (3) uniformly rising front, (4) damped sinusoid, and (5) difference of two exponentials.

Attenuation and Distortion

Bewley continues that it usually is justifiable and convenient to perform traveling-wave calculations on the assumption of no losses, and then to compensate for attenuation by an exponential decrement factor

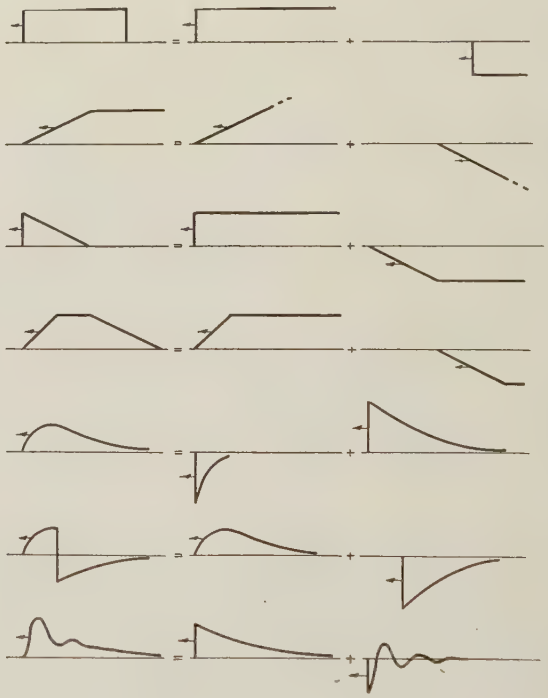


Fig. 5. Separation of complex waves into two simple waves

determined experimentally. Corona, it is generally agreed, is the chief cause of attenuation and distortion. It levels off the top and elongates the wave, but its effect is somewhat variable depending upon the weather and other conditions.

Effects of line losses are threefold; (1) voltage and current waves are attenuated, (2) wave shapes are distorted with time, and (3) the waves depart from exact similarity, so that the simple linear proportionality

factors (called the surge impedances) and the linear equations cease to hold except as approximations. Skin effect and normal line losses, according to Bewley, are of minor importance and may be neglected in comparison with corona losses.

Brune and Eaton in discussing the theoretical aspects of their line tests state that the very front of the wave suffers the greatest attenuation (becoming less and less steep) the net result being that the entire wave is lengthened and the crest voltage is reduced. This is caused not only by corona, but also by skin effect and series resistance in the line. Attempts to calculate the effect of corona by assuming an equivalent "leakance," however, are stated to be erroneous, since the corona does not establish a conducting path by means of which charges may leak off the line except at voltages near sparkover values.

To clarify somewhat the mechanism of corona, Brune and Eaton explain that usually the area surrounding a conductor becomes conducting only within an envelope of limited radius, and as the voltage rises above the

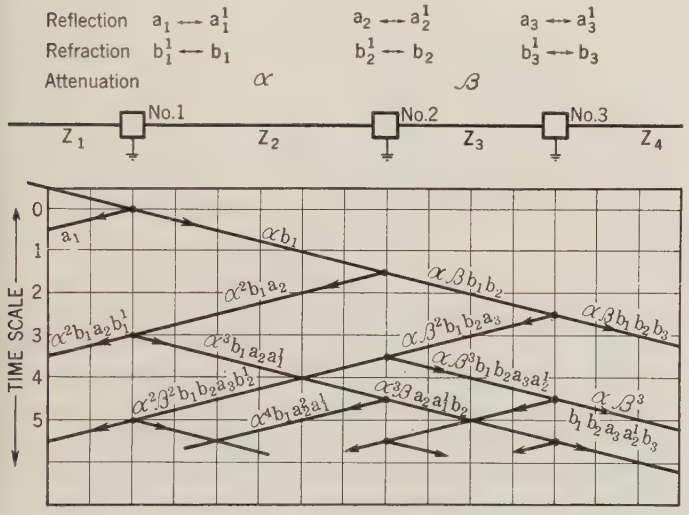


Fig. 6. Typical lattice diagram for computing successive reflections

corona voltage, charges enter this envelope thereby decreasing the voltage on the front of the wave. Such charges will remain in the corona envelope as long as the conductor voltage is high; when it falls the charges return to the conductor thus tending to maintain the high voltage on the tail of the wave. In this exchange of charge between conductor and corona envelope energy is lost, but no charge.

Successive Reflections

In a number of important problems, such as in the theory of ground wire, the effect of short lengths of cable, and trunk lines tapped at short intervals, it is necessary to consider the effects of successive reflections of traveling waves. Difficulty sometimes is experienced in keeping track of such reflections where numerous reflecting points exist. To solve this difficulty lattice diagrams have been devised which show at a glance the position and direction of motion of every incident, reflected, and refracted wave on the system at every instant of time. In Fig. 6 a typical lattice diagram has been set up for a line containing three reflection points. These reflection points may consist of any combination of impedances in series with the line or shunted to ground. The circuits between these points may consist either of open lines or cables, and may have different surge impedances, velocities of wave propagation, and attenuation factors.

To construct such a lattice for any particular case it is necessary only to scale the junctions at intervals equal to the time taken by the wave to traverse each section between junctions. A suitable time scale then can be chosen (shown as the ordinate in Fig. 6) and the diagonals drawn in.

Reflection and refraction operators can be placed at the top of the lattice over the respective junctions with suitable directional indicators. These may be seen at the top of Fig. 6 where a and a' are respectively the reflection operators for waves approaching from the left and right, b and b' are respectively the refraction operators for waves approaching from left and right; α and β are attenuation factors for the sections between junctions. These operators, of course, are operational expressions involving the impedance functions of the junctions, but no restrictions are placed on their generality. Starting at the origin of the initial incident wave at the top of the lattice, the reflected and refracted waves at each junction can be obtained by applying the operators of that junction to the incident wave arriving there, then proceeding until the lattice has been completed. In these lattice diagrams it will be observed that:

1. All waves travel "down-hill."

2. The position of any wave at any time is determined from the vertical time scale at the left of the lattice.

3. The total potential at any point at any instant of time is the superposition of all the waves which have arrived at that point up to that instant of time, displaced in position from each other by intervals equal to the instants of their time of arrival.

4. The previous history of any wave is easily traced.

5. The effect of attenuation is included.

6. If it is desired to carry the computations to a point where it is not practical to place the various operators directly on the lattice itself, then

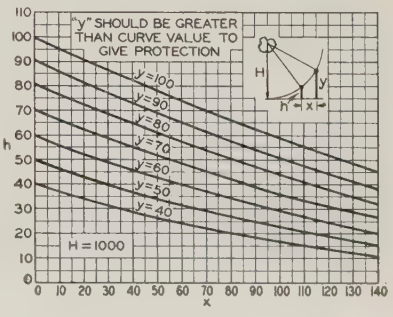


Fig. 7. Minimum ground wire heights (y) to shield line conductors against direct strokes from clouds 1,000 ft. above

the arms may be numbered and the operational expressions tabulated in a suitable form.

Dowell has used this method in analyzing the results of some of his investigations with artificial lightning impulses applied to typical sections of lines. These are treated in another part of this symposium.

OVERHEAD GROUND WIRES

To protect line conductors from direct hits the ground wire or wires should be at a sufficient distance above the line wires to "attract" the lightning. Peek has found that the shielding effect of ground wires depends not only upon their vertical height but also upon the horizontal distance between their projections and those of the line wires. Fig. 7 shows minimum values for the ground-wire heights required to protect the line wire against direct hits from a cloud 1,000 ft. above the earth. The respective heights for the line and ground wires are represented by h and y, and the horizontal distance between by x.

While this position for the ground wire may shield the line wire from the initial hit, it does not protect against side flashes or sparkovers from a struck ground wire to a line wire, where the hit takes place at some distance from a tower.

Hazards due to direct hits of this nature can be reduced by special provision in ground-wire design and tower spacing, but usually these are considered unnecessary since the chance of a hit between towers is small.

Even with ground wires installed, however, immunity from outages due to direct hits can be approached only with low tower footing resistance to maintain low tower potentials, and with heavy line insulation. In some cases in addition to the overhead ground wires with which lines now usually are equipped, "direct-stroke" wires strung above the ground wires may be necessary to prevent flashovers from midspan hits. The advantageous effect of short span construction can be simulated by supporting the ground wire not only from the main towers, but also from intermediate towers interposed between the main towers. Low-footing resistance usually can be obtained by means of buried (counterpoise) wires connected to the tower legs. The adoption of such an expedient will be governed, however, largely by cost considerations.

In rocky and mountainous country where it is difficult to obtain low tower footing resistance special ground-wire construction or line shielding may be necessary. It is possible also to prevent outages by some form of device at the tower which would permit lightning to discharge freely to ground, but which would prevent power current from following. One such device which is operating successfully is the fused grading shield. Other devices have been brought out, but still are largely in the experimental stage.

Formation of line surges due to lightning strokes is analyzed by Fortescue and Conwell in accordance with the type of transmission construction used. Their two classifications are (1) wood pole lines and steel tower lines not equipped with ground wires, and (2) steel tower lines equipped with ground wires.

Considering first wood pole lines unprotected by ground wires or spill-over gaps, the potential attained by a surge before the structure breaks down may be very high. When the structure flashes over, the potential is reduced quickly to a value which depends upon the surge impedance of the conductor and of the wood poles and ground. Some simple calculations using accepted formulas and constants show that a stroke which would deliver a 15,000-kv. surge on a single line conductor will appear at 77 per cent of this value on all three line conductors when all three are struck. Under such conditions flashover to ground will occur immediately, but a potential of about 30 per cent of the original surge will still exist. In the case of steel towers without ground wires the surge potential of the conductor after flashover will be the same as that of the tower so that one insulator string only may be flashed over if the surge impedance of the tower is low. The likelihood of another flashover taking place at adjacent towers is dependent upon the intensity of the stroke and the impedance of the tower circuit where flashover first occurs.

Where ground wires are used on steel tower construction, assuming that the protection is adequate, flashovers still may occur if the line is inadequately insulated. When a bolt strikes the ground wire at midspan the resulting surge will travel to adjacent towers where part of it will be absorbed by the tower, part will continue on the ground wire, and part will be reflected. Flashovers may occur between the towers and one or more conductors, so that towers, ground wires, and affected conductors will assume the same potential. Flashover also may take place at midspan between conductors and ground wire; the conductor potential then will be of sufficient magnitude to cause an additional flashover at an adjacent tower.

In a well protected, well insulated line a stroke to the ground wire in midspan or to a tower is quickly reduced by reflections from adjacent towers and becomes of very small magnitude three spans distant from the point hit. Calculations indicate that where tower footing resistance is low, insulator flashover is not likely to occur. In all cases where flashovers do not occur either at midspan or at towers, potentials induced on the conductors by coupling will become negligible beyond the region of the disturbance. In such cases no surge will be propagated over the line to terminal apparatus and the line will continue to operate unaffected by the lightning stroke.

Field Tests with Artificial Lightning

High-voltage impulses simulating lightning surges can be impressed on a line at will, and now provide the most convenient means for studying the characteristics of such waves. Corona is found to be the greatest cause of wave attenuation and distortion; to a lesser extent, skin effect.

IN THE first class of field investigation described, high-voltage impulses were impressed upon the line and cathode-ray oscillograms taken at different points along the line. By comparing oscillograms of the original wave with those taken out on the line, information was obtained regarding the general behavior of traveling waves with particular attention given to attenuation and distortion. In the investigation described by Dowell, oscillograms were taken at the point of impulse-generator connection only. These tests were made with an oscillograph having a comparatively slow sweep, the principal object being to determine the effects of reflections.

To obtain the high-voltage surges, a lightning impulse generator designed especially for this class of investigations was used. Both this apparatus and the cathode-ray oscillograph have been described in detail in previously published articles.

Brune and Eaton report upon the results of a test of the first type mentioned which was made jointly by the General Electric Company and the Consumers Power Company (Mich.) on the Croton Dam-Grand Rapids 75-kv. line of the latter company. Line data and other features of these experiments are given in Table II. Because previous sphere-gap tests showed that the rate of attenuation is affected by voltage, polarity, and distribution of the charge over one or more conductors, test wave shapes were chosen to accentuate these features.

Factors Affecting Wave Propagation

A group of typical cathode-ray oscillograms replotted to uniform time and voltage scales is shown in Fig. 8. It may be noted that attenuation is much more rapid above corona voltage than below it (the calculated critical corona voltages for this line being 85 and 125 kv. for surges on one and on three parallel conductors, respectively).

These waves support the theory that in the mechanism of corona, as previously outlined, (1) the area surrounding a conductor becomes conducting only within an envelope of limited radius; (2) when the voltage rises above the corona voltage, charges enter the envelope and remain there until the conductor voltage falls, returning then to the conductor and thus holding up and flattening out the tail of the wave. The process can be likened to the discharge of one condenser into another through a resistance, the difference being that on a transmission line the quantities are distributed rather than lumped, and are variable depending upon the voltage.

It may be noted, however, that other factors besides corona appear to affect the propagation of the surges. This is brought out clearly in those oscillograms where the crest voltage is below the critical corona value. Such waves exhibit changes in form which might be caused by line resistance, the general effect observed being a continuous attenuation of the front of the wave, a reduction in crest voltage, and lengthening of the wave tail. This is accounted for by the variable character of the line resistance due to skin effect as explained in another article of this group.

Lewis and Foust attribute the flattening of the wave front and lengthening of the tail to the lower velocity of propagation for the high-voltage portion of the wave, but that such a point of view must not be accepted finally as an explanation of the mechanism of surge propagation without a closer examination than has yet been given. These authors state further that the influences of corona and polarity upon surge propagation have been shown to be great and that both probably are determining factors. Conditions of relative energy loss on the front, crest, and tail of the wave, however, are said to be but little understood, the shift of energy relations within the wave possibly accounting for wave changes which have been demonstrated.

Attenuation

Attenuation curves for several tests showing maximum voltage against miles of wave travel are shown in Fig. 9 (Brune and Eaton). The effect of polarity upon attenuation is evident in these curves at once, the positive surges being attenuated more rapidly than the negative surges, especially by corona. In comparing waves I and J with waves A and B, it may be noted also that short waves are attenuated more rapidly than are long waves.

To draw a comparison in attenuation between waves on one and on three parallel conductors, respectively, reference is made to curves C and I (which have approximately the same length at a voltage of about 600 kv.). It may be seen readily that surge C attenuates more slowly than surge I; the same comparison may be drawn between surges D and J. It seems obvious, therefore, that a surge on three conductors will attenuate more slowly than a corresponding surge on one conductor. This is in accord with the fact that

where the same voltage is applied to three parallel conductors the voltage gradient will be less than around a single conductor. Therefore, the effect of corona (which is considered the greatest single contributing factor) will be less for three conductors than for one.

Reflections

The experiments described by Dowell were made on the 132-kv. Philo-Canton line of the Ohio Power Company (see Table II). The oscillograph in this case was coupled to the line at the point of connection of the lightning impulse generator. The voltage measured is the sum of the incident and reflected waves, the two components being entirely different in magnitude and shape. Crest voltages of the applied waves were obtained by sphere-gap measurements, and the voltages of successive reflections by comparative deflections on the oscillograms. All waves in these tests were applied to a single line either grounded or open-circuited at the far end. According to Dowell, if the applied wave

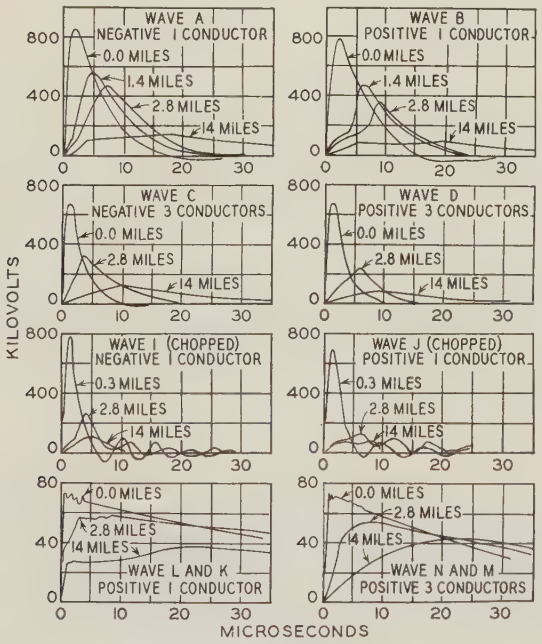


Fig. 8. Typical oscillograms replotted to uniform scales to illustrate change in wave shape with travel along the line

is of the order of two or more times the length of the transmission line, successive reflections are superposed on one another and the individual waves must be segregated before attenuation constants can be obtained. This segregation was facilitated by use of the lattice diagrams described by Bewley in another part of this symposium.

Reflection and refraction operators were derived mathematically for the existing line and terminal conditions. When applied to the function of time representing an incident wave, these operators give respectively the differential equations, the solutions of which are the reflected and refracted waves. This mathematical work was facilitated by the use of Heaviside's operational calculus. Attenuation constants were determined by comparing the calculated values with the oscillogram measurements. This method of attack seems especially applicable to cases wherein the wave of the applied impulse is long enough to permit a

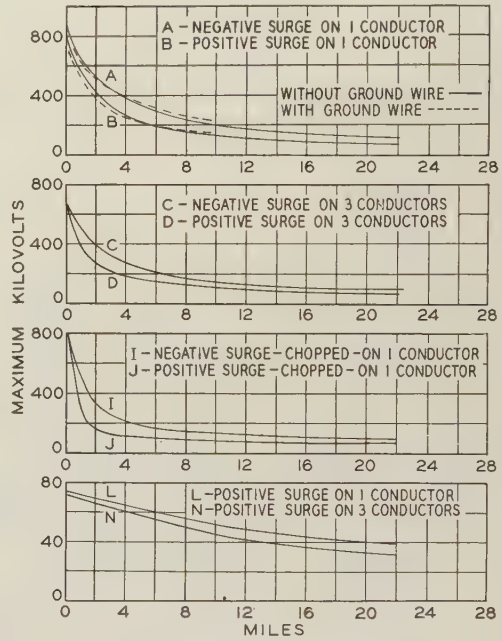


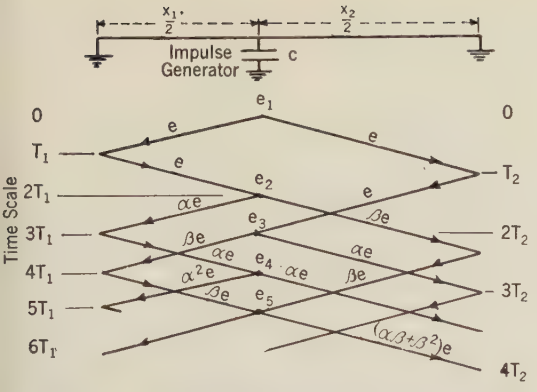
Fig. 9. Reduction in crest voltage of typical traveling waves

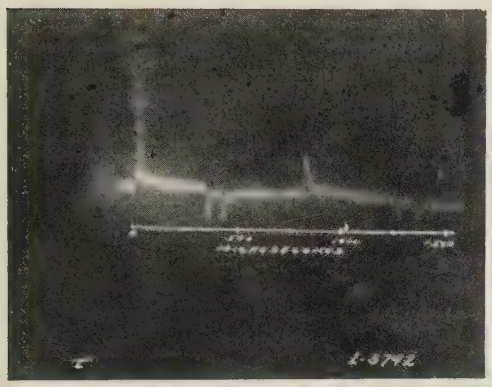
reflection to return to the point of measurement before the original wave has completely passed that point.

A typical lattice diagram for a typical line condition with an oscillogram taken at the lightning generator under the same condition may be seen in Fig. 10. The various crests in the oscillogram show definitely the effects of successive reflections especially at the fifth wave crest where reflections from both ends of the line are superposed.

Discussing attenuation on the basis of his results, Dowell agrees that the principal causes of wave attenuation and distortion are corona and, to a lesser extent, skin effect. However, he states that artificial lightning waves may attenuate considerably without an appreciable change in shape, other than some slowing down of the crest. From these findings it is thought permissible to treat such traveling waves as though the line were distortionless, in which case the attenuation is accounted for by a simple exponential decrement factor. Waves calculated under these conditions check quite closely with oscillogram measurements as may be seen from Fig. 11.

Dowell states further that while the segregation of





Typical comparisons between calculated waves and actual measurements

Fig. 10. (Left) Lattice diagram with oscillogram taken at point C for line condition shown. Note peak at fifth wave crest where two reflections are superposed (e_5 in diagram)

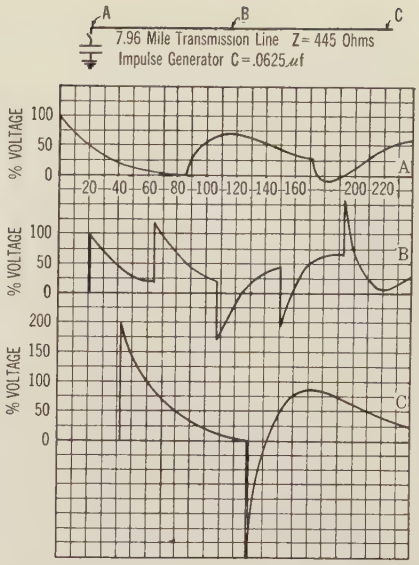
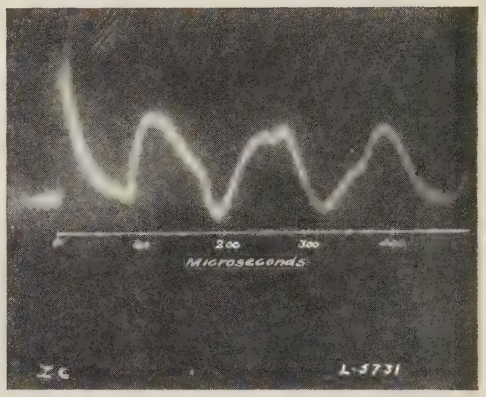


Fig. 11. (Right) Voltage-time relations for traveling wave on line open at one end; (above) computed curves; (below) oscillogram at point A



the attenuation from successive reflections is a long and laborious process subject to errors both in the mathematical and oscillographic work, the calculations demonstrate once more that traveling waves on transmission lines may be computed with excellent engineering accuracy by treating the line as distortionless.

Induced Voltages in Parallel Conductors

The theory of induced surges in parallel conductors developed by K. W. Wagner for the non-dissipative line, leads to a set of simultaneous linear equations expressing surge voltage on any conductor in terms of the surge currents on all the conductors. The usual convention of regarding all voltages as being composed of two traveling waves proceeding in opposite directions is observed. Because of the linear relationships in these equations an induced surge will have exactly the same wave shape as the inducing surge. An isolated conductor will have a potential due to its position in the field, but no current along the conductor.

Sphere-gap measurements of induced voltages made in 1929, however, showed that the ratio of induced to inducing voltages increased as the surge proceeded along the line. Since attenuation was also in evidence it followed that the theory of the non-dissipative line would not hold accurately.

Further light is thrown upon this phenomenon by oscillograms obtained by Brune and Eaton, a selection of which appears in replotted form in Fig. 12. In these oscillograms it may be seen that the wave shapes of induced and inducing surges differ widely. For both positive and negative waves the voltage of induced surge is lower at the beginning and higher later on than that which would be due to the field of the inducing surge alone, while the negative induced surge is actually of opposite polarity at the beginning. This peculiarity in the induced wave cannot be attributed to corona

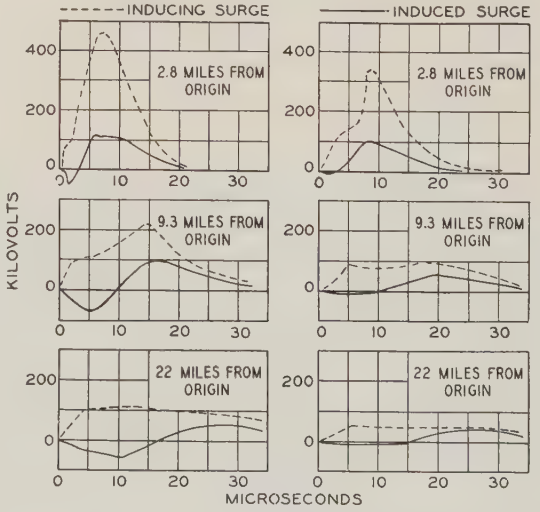


Fig. 12. Replot of induced and inducing surges on free conductor for both negative (left) and positive (right) inducing impulses

effects; the same conditions have been found to exist on surges below the critical corona voltage.

In an attempt to arrive at some conclusion in regard to this effect, Brune and Eaton say that there appears to be a continuous separation of charge taking place within the induced surge. A charge having polarity opposite to that of the main surge is thought to collect in front of the induced surge, thus decreasing the resultant voltage there, while charge of the same polarity increases the voltage in like manner in the latter portion of the induced surge. The mechanism by which this separation takes place is not at all clearly understood, but it seems to be connected in some way with the process of attenuation and distortion of the main wave. Thus it appears that not only is the self-surge impedance no longer a constant for wave propagation on a dissipative line, but also that the mutual surge impedances have become more complicated. This theory would account for the flattening in wave crest noted in Fig. 8, waves *C*, *D*, and *N*.

Field Tests With Natural Lightning

Although lightning surges of as high as 5,000 kv. have been recorded, only about ten per cent of these have crest voltages of more than seven times normal line voltage. One important result of recent investigations is the proof that a direct stroke can occur to a tower or ground wire without causing a flashover.

NATURAL LIGHTNING INVESTIGATIONS, as may be implied, differ from the experiments just related mainly in that the tests and measurements were confined to natural lightning discharges occurring during storm periods, and the resulting line surges. Accordingly the results have been correlated with line flashovers, faults, and general system performance. A few measurements were obtained at points very close to actual direct strokes. The effects of special ground wire construction, tower grounding cables, counterpoises, and various other protective measures were investigated.

Inasmuch as these investigations were conducted for the most part with the lines in operation an opportunity was afforded for evaluating the results in terms of actual operating experience.

Test Equipment and Instruments Used

Besides the cathode-ray oscillograph which has found universal application in all lightning surge studies, the klydonograph also has been used to a large extent for making both voltage and current measurements. Surge-voltage recorders, also well known in this class of work, have been used in many cases. The field intensity recorder described in previously published articles also has found some application. Three new devices, developed especially for this sort of investigation and used in some of the more recent tests, are:

1. Direct-stroke recorder.

This instrument consists essentially of a small klydonograph with timing accessories omitted, and is built into an ordinary telephone receiver. It usually is coupled directly to the transmission-line tower through a resistance potentiometer. (See Fig. 13)

2. Surge or flashover indicator.

This is a small device which can be applied to each insulator assembly on a tower and is so designed that an indication visible to a ground patrolman will show after a flashover on that assembly has occurred.

3. Storm-severity meter.

This consists essentially of a roll-film box camera containing a special glow tube, the tube being connected between a 30-ft. vertical antenna and ground. Collapse of electric charges collecting on the antenna during storms causes the tube to glow and record a spot on the film; thus the intensity or degree of darkness of this spot is an indicated function of the number of charges on the antenna and their magnitude.

The lines on which these investigations have been carried out are indicated in Table II (see also Fig. 15). Line construction data are given with special features noted; instruments used in each case are listed to give some indication of the scope of each investigation. Unusual features of each investigation are noted also.

The results although sometimes difficult to interpret nevertheless reveal many interesting aspects of the lightning situation and the line protection problem. Wherever possible attempts have been made to correlate system disturbances directly with either direct strokes or induced surges. The inconsistencies which still exist are due partly to an incomplete understanding of the fundamental nature and behavior of lightning, and partly to the widely varying nature of the lightning discharge itself.

Direct and Induced Strokes

That effective measures for protection may be adopted, it is necessary first to distinguish between direct and induced strokes, the relative magnitudes of their potentials, and the frequency of occurrence and other characteristics, and then to evaluate these in the light of system performance. That direct strokes to line conductors nearly always cause flashovers and trip-outs, is quite generally agreed; and that direct strokes to ground wires or towers often do also. In-

TABLE II—Line and Instrument Data with Special Features of Field Investigations

Name and location	Line Data: Operated by	Operating kv.	Miles of line under test	Structures	No. circuits	Configuration	Other features	Instruments used	Special features of investigations
Croton Dam-Grand Rapids (Michigan)	Consumers Pwr. Co.	70	45	Steel tower	1	Vert.	1. One ground wire throughout	1. 1,500,000-volt impulse generator 2. Cathode-ray oscillographs	1. Characteristics of surges induced in parallel conductors investigated. 2. Effects of tower counterpoises studied.
Philo-Canton (central Ohio)	*Ohio Pwr. Co.	132	73	Steel tower	2	Vert.	1. One overhead ground wire throughout 2. Two lightning arresters installed on line	1. Surge voltage recorders 2. Cathode-ray oscillographs 3. Direct stroke recorders 4. Flashover indicators 5. 1,000,000-volt impulse generator	1. Two investigations made: (1) attenuation and reflection experiments with artificial lightning surges; (2) a study of natural lightning disturbances. 2. Surge voltage recorders installed on two 132-kv. lightning arresters. 3. "Double-sweep" cathode-ray oscillograph used (see Fig. 14).
Roseland-Siegfried & Roseland - Plymouth (central and southern N. J.)	Pub. Serv. Elec. & Gas Co.	220	6	Steel tower	1	Horiz.	1. Two ground wires throughout 2. Arcing rings on all insulator strings	1. Portable 1,000,000-volt "lightning" generator 2. Cathode-ray oscillographs 3. Klydonographs	1. Tests made while lines were under construction. 2. Flashovers related to ground wire protection and tower footing resistance. 3. Lightning currents measured by klydonographs installed directly in parallel with power footings.
Wallenpaupack-Siegfried (eastern Pa.)	Penn Pwr. & Lt. Co.	220	65	Steel tower	1	Horiz.	1. About 37% of line equipped with two overhead ground wires 2. Counterpoises on 2.5-mi. section 3. 80 towers fitted with grounding cables 4. 3.5-mi. section with overhead diverting cables	1. Cathode-ray oscillographs 2. Flashover indicators 3. Surge voltage recorders 4. Direct stroke recorders 5. Magnetic oscillographs and high-speed recorders 6. Field-intensity recorders 7. Rate-of-change-of-field recorders 8. Storm severity meters	1. Fast- and slow-sweep cathode-ray oscillographs used. 2. Antennas installed for measuring induced voltages. 3. Two lightning arrester installations 4. Effects of direct-stroke diverters and special tower grounding investigated.
Deepwater - Pleasantville (southern N. J.)	*Atlantic City Elec. Co.	132	30	Steel tower	2	Vert.	1. Two ground wires in vertical plane through center of tower over entire length of line 2. Arcing rings at both ends of insulator strings	1. Direct-stroke recorders 2. Surge-voltage recorders 3. Flashover indicators	1. Study of induced and direct strokes made with particular attention to resulting flashovers and outages. 2. Line designed for 132 kv., but operated at 66 kv. during entire test period.
Turner-Logan, Glen Lynn-Roanoke, & Turner-Cabin Creek (western parts of Va. & W. Va.)	*Appalachian Elec. Pwr. Co.	132	59	Steel tower	2	Vert.	1. One ground wire throughout 2. Conductors on two sides of towers in reverse-phase order 3. Grading shields and horns on all insulator strings 4. Tower footing resistances high	1. Klydonographs 2. Cathode-ray oscillographs 3. Direct stroke recorders	1. Four-year study of natural lightning disturbances. 2. Data were obtained on one line both before and after the installation of a ground wire. 3. Klydonographs installed on lightning arresters at substations. 4. Line flashovers correlated with tower elevation.
Camden-Magnolia (southern Arkansas)	Ark. Pwr. & Lt. Co.	110	28	Wood pole	1	Horiz.	1. Fused horn-gaps from each phase to ground at 1-mi. intervals except in 9-mi. section near oscillograph station	1. Cathode-ray oscillographs 2. Klydonographs	1. Behavior of lightning surges on a highly insulated wood pole line observed. 2. A new arrester of the air-expulsion type tried out.

*Subsidiaries of American Gas & El. Co.

Fig. 13. Direct-stroke recorder installed at base of tower

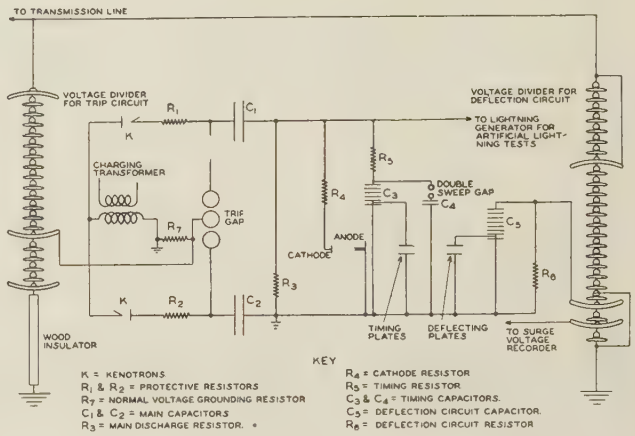


Fig. 14. Circuit diagram for a "double-sweep" cathode-ray oscillograph

duced surges, either from cloud discharges unaccompanied by stroke to earth, or from direct strokes to nearby objects, may in some cases be sufficiently high to cause flashovers and line trip-outs. The probability of induced voltages causing line outages is greatly reduced by overhead ground wires, and also depends to a large extent upon tower footing resistance and line insulation.

Bell and Price, in reporting the results of extensive investigations pursued on the 220-kv. transmission system of the Pennsylvania Power & Light Company, state that direct strokes usually contact only one object (ground wire, power conductor, or tower top) and do not fork to other objects (power conductors for instance) in the same vicinity. They also state that voltages induced in the conductors by the collapse of cloud fields do not appear to endanger service over circuits as highly insulated as the lines in question. In their investigation an attempt was made to determine the approximate magnitude of induced surges by measuring the voltage induced in a 100-ft. antenna installed near the line, but not coupled to it. A potential of from 2,700 to 3,150 kv. was measured on this antenna, but the corresponding voltage induced in the line conductor was only about 350 kv. In no case could extremely high voltages measured on the transmission line be correlated with those measured on the antenna.

During this same investigation an oscillogram was obtained of a direct stroke of negative polarity which occurred not more than 500 ft. from the lightning laboratory and which caused a trip-out and single-phase fault. This oscillogram is shown in Fig. 16. As may be noted, the voltage rise was rather gradual for the first 3.5 microsec., but was quite rapid during the next 2 microsec., until the insulator flashed over on the crest of the wave at a potential of more than 2,760-kv., the maximum range of the oscillograph.

Another interesting record of a direct stroke is that obtained by Gross and Cox. (Fig. 17.) This represents a klydonograph record, simultaneous records being obtained by both the direct-stroke recorders and cathode-ray oscillograph. The line (Turner-Logan) tripped out three times within 20 minutes during this storm, but the only flashover which could be located by inspection after the storm, was on the top phase of the tower adjacent to that at which the klydonogram was obtained.

Two cases are reported by Sporn and Lloyd wherein trees were struck at points quite near the line. In one case two trees respectively 500 and 1,500 ft. from the line were struck. The nearest surge-voltage recorder (more than a mile away) indicated two highly damped surges of -4.8 and $+2.4$ times normal voltage, but it was impossible to correlate either stroke with a line trip-out or even a flashover. By a peculiar coincidence another tree at this same point had been struck previously. This tree was 360 ft. from the line and near the 500-ft. tree mentioned in the other case. At that time the surge recorder (located at an adjacent tower) indicated a positive maximum voltage of 2,100 kv. A trip-out occurred apparently caused by the high voltage induced from the direct stroke to the tree. These two cases well illustrate some of the inconsistencies encountered.

Lewis and Foust comment on the question of direct and induced strokes as follows:

"Apparently there is evidence to the effect that direct strokes play an important part in transmission flashovers and outages. There is a great deal of evidence that induced strokes also are highly important. There is insufficient evidence at the present time to evaluate more exactly these two types of strokes."

Crest Values of Lightning Surges

As might be expected the crest values of lightning voltages and currents are subject to many variations also. Bell and Price report a maximum voltage well above 3,000 kv. (see Fig. 16) measured at a point not more than 500 ft. from the stroke. Currents from less than 40,000 to about 260,000 amperes are indicated in their report.

Voltage measurements from a 4-year study are plotted by Gross and Cox as shown in Fig. 18. Volt-

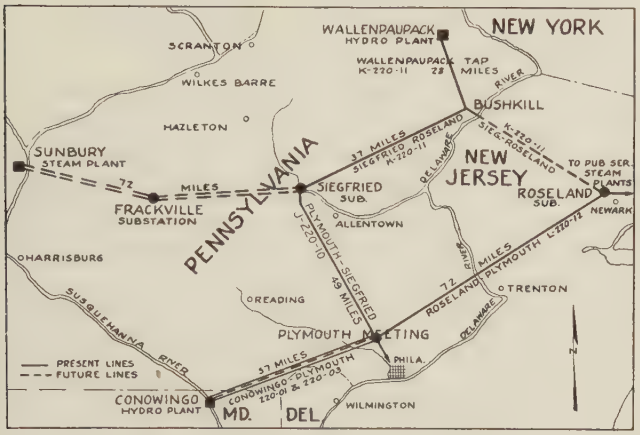
ages of surges due to switching also are shown in this diagram. The maximum lightning voltage recorded was about 26 times normal, or 2,800 kv. It may be noted that only 10 per cent of the surges were of more than seven times normal line voltage. It has been computed also that the lines involved in this investigation (Appalachian Electric Power Company) are subject to 4.6 lightning voltages of 15 times normal per 100 mi. of line per year. Compared to other published data this would show that the lines in this territory are subjected to lightning disturbances of greater than average severity.

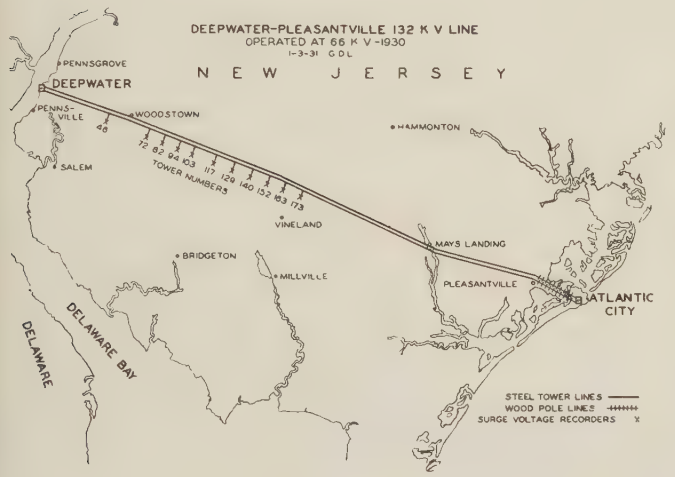
In the same investigation similar results were obtained for lightning voltages appearing at substations. In this case the highest lightning voltage recorded was only twelve times normal while only 4.5 per cent were more than seven times normal. This reduction is attributed to the lightning arrester protection installed at substations and also to the number of paths into which an incoming surge can be dissipated.

Sporn and Lloyd report a maximum lightning voltage obtained (Philo-Canton line—1930) by surge recorders of only 6.5 times normal (700 kv.). The low severity of lightning storms during that year in that section of the country is believed to be the reason for the absence of higher voltage measurements. Discharge currents of from 40,000 to 670,000 amperes were indicated, however, (by adding the tower currents), the current distribution for a typical case being shown in Fig. 19. These values are subject to a certain amount of error because of the fact that all currents may not have been recorded simultaneously. Reflections at points of changing surge impedance also would affect the measurements.

Lewis and Foust have plotted (see Fig. 20) the results of lightning voltage as measured by surge-voltage recorders based on a study of 678 lightning surges occurring on fourteen systems during the years 1926-1930 inclusive. Voltages due to switching are shown also, based upon 724 surges occurring during the years 1927-1930 inclusive on practically the same systems from which the lightning data were taken. These curves are in close agreement with those obtained by Gross and Cox.

All of the results mentioned so far have been concerned with lines having steel supporting structures.





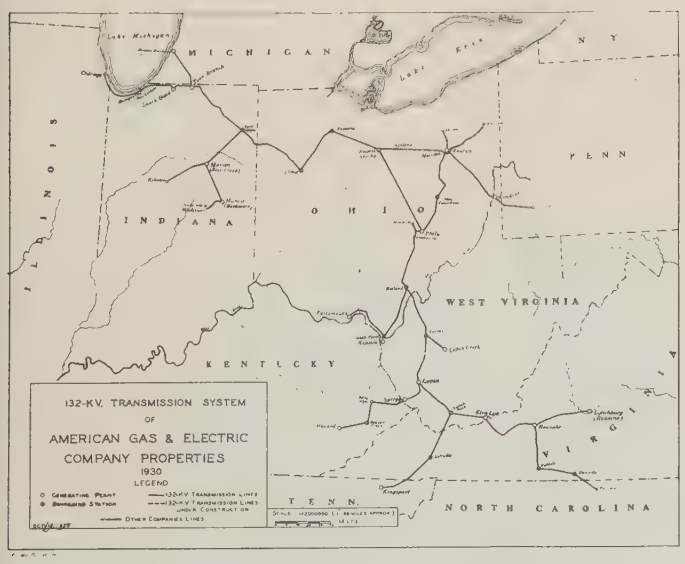


Fig. 15. Some of the lines upon which lightning investigations of the past few years have been concentrated

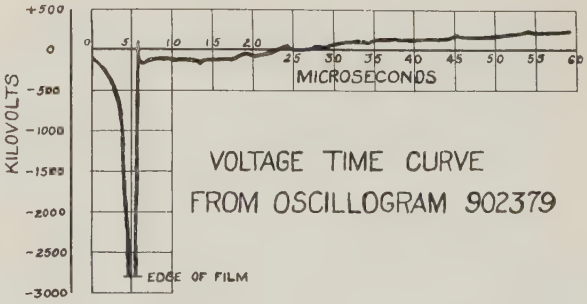


Fig. 16. Oscillogram of a direct stroke taken about 500 ft. from point of stroke and 125 ft. from insulator flashover; flashover occurred also at an adjacent tower and was followed by a line trip-out

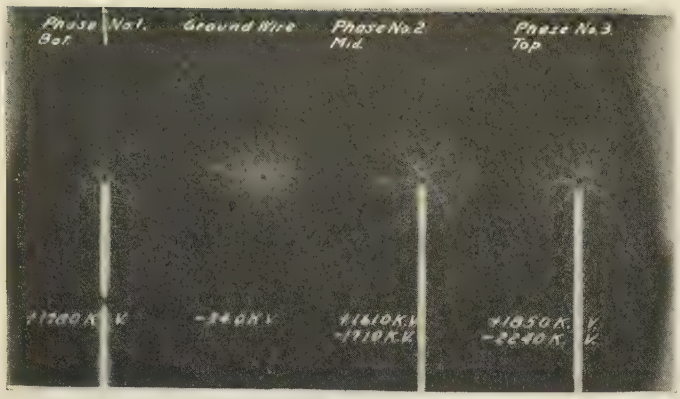


Fig. 17. Klydonograph record of a lightning surge

Negative surges are indicated on ground wire and two top conductors; positive surges are in evidence on all line conductors. A simultaneous cathode-ray oscillogram showed the disturbance to be oscillatory. (Important details of klydonograph records are unavoidably lost in reproduction.)

Much higher voltages due to lightning have been reported by Pittman and Torok in their tests on the Camden-Magnolia (Ark.) 110-kv. wood-pole line. On this line pole-grounding wires are installed only on guyed structures which normally are about one mile apart. The maximum voltage recorded in the investigation was approximately 5,000 kv. measured at a point about 4 mi. from the point of stroke (see Fig. 21). The indicated rate of potential rise is about 4,000 kv. per microsec. These values contrast sharply with the maximum reported on steel-tower lines. It appears quite obvious that the voltage of the discharge if measured at the point of incidence would have been much higher than the voltage measured 4 mi. distant, although the actual maximum value is a matter of interesting speculation.

An examination of the surroundings near the point of discharge of this bolt showed that an arc had been established from a line conductor to a telephone wire crossing 22 ft. below the line. In addition both 50-ft. poles on the H-frame supporting structure adjacent to the telephone line crossing were splintered. Allowing 350 kv. per ft. as the breakdown strength of air, a potential of 7,500 kv. would be required to flash from conductor to telephone line. However, since corona loss at such high voltages is tremendously high, it is quite obvious that a 2,500-kv. difference is not sufficient to account for the voltage lost in 4 mi. of travel. These facts would tend to place the voltage of the original stroke at a value somewhat higher than 7,500 kv.

Flashovers and Trip-Outs

Of the 65 line insulator assemblies flashed on the 220-kv. Wallenpaupack-Siegfried line, Bell and Price report that 71 per cent showed glaze burns characteristic of dynamic arcs. Of 38 flashover indicator operations, 29 (76 per cent) were associated with marked insulator assemblies. Most of these flashovers occurred on phase conductors occupying the outer positions on the towers. Some 24 trip-outs were associated with the 65 flashovers most of these being accompanied by single-phase faults. Their results show in addition that 32 flashovers out of 36 involved only one phase, but that in 15 of these 32 more than one insulator assembly was flashed over.

Gross and Cox state that of the surges higher than 600 kv. recorded in their investigation, thirteen were associated with line trip-outs while ten were not. They account for the existence of high-voltage surges (higher than the 60-cycle line flashover voltage) without flashover and trip-out by the fact that when a direct hit to a tower occurs the tower potential is altered with respect to ground because of its surge impedance and footing resistance; although the voltage to ground may be higher than the line flashover value the voltage between line and tower may be somewhat less. This explanation, however, does not account for the absence of trip-outs in all cases, and it is believed consequently that lightning flashovers sometimes may occur without subsequent power arc and line outage.

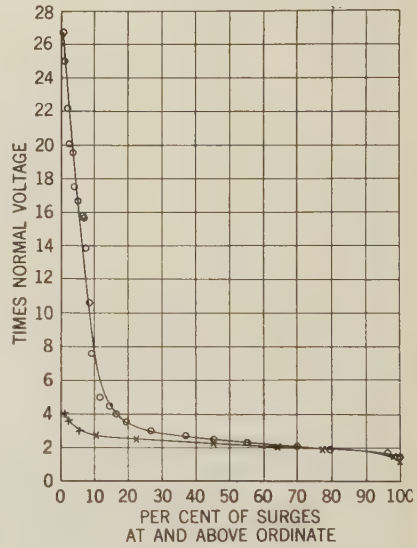


Fig. 18. Surge voltages reported by Gross and Cox for the period 1927-30 inclusive (based upon 143 lightning and 98 switching surges)

In attempting to correlate these trip-outs with tower footing resistance and line elevation, these authors definitely state that, "an attempt to relate line flashovers to tower footing resistance proved futile." As regards tower elevation, there was some tendency for flashovers to concentrate near high points in the line contour, which experience is in accord with the reasonable expectation that lightning will strike the most exposed points; these, of course, being the points of highest elevation.

In the results obtained by Sporn and Lloyd during 1930 on the Deepwater-Pleasantville 132-kv. line, twelve direct strokes were recorded, only three of which could have resulted possibly in a trip-out, while on the 30-mi. section of the Philo-Canton line thirteen

direct strokes were recorded, only one of which possibly could have produced a trip-out. Of a total of 107 surges recorded in Ohio only 33 per cent were due to lightning, 60 per cent being due to switching. Notwithstanding the many surges recorded, only four trip-outs occurred, three of which involved both circuits. There were indications, however, that flashovers had occurred in some cases where trip-outs had not.

Pittman and Torok state that on the wood pole line upon which their investigations were made, voltages as high as 2,000 kv. were recorded without any switch operation. This was not thought particularly surprising since the line was equipped with several drain points set to operate at about that voltage. General experiences on this line have pointed to the conclusions that voltages of a harmful character occur only when direct strokes or their branches terminate on the conductors, and that trip-outs on ungrounded wood pole construction usually result from phase-to-phase flashovers.

Lewis and Foust outline three conditions under which line insulation may flash over as a result of direct strokes. They are (1) a stroke to line conductor, (2) a stroke to the tower, and (3) a stroke to the ground wire

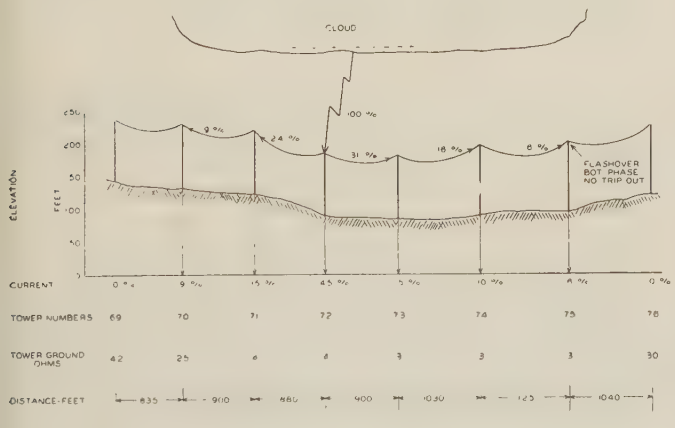


Fig. 19. Typical lightning current distribution on either side of a struck tower

between towers where the potential is such that flashover will occur between ground wire and line conductor. Direct strokes to line conductors appear to be of rare occurrence where steel towers and overhead ground wires are used. Where insulator flashover does occur under these conditions, it apparently results through high tower potentials caused by high footing resistance.

It is further stated that where flashover does occur from tower to conductor the spread to other insulator assemblies on the same tower may be prevented by the resulting reduced impedance between tower and ground. Experience has shown also that a flashover is not necessarily followed by a line trip-out. A permanent arc is not set up because the power voltage to ground and conductor current do not have sufficient amplitude and proper polarity relations to establish it.

Extent of System Affected

The extent to which a transmission system may be affected by lightning discharges appears to depend mainly upon line design and insulation; also upon whether or not flashover occurs at or near the point of incidence. On steel-tower lines where flashover occurs, experience has shown that the disturbance is limited to five or six adjacent towers, flashover in most cases occurring on one phase only, but in many cases on two insulator assemblies at adjacent towers.

Fortescue and Conwell state that if a tower or ground wire is struck and no flashover results, severe electrical disturbance is limited to a few structures, and any surge propagated over a conductor will be of extremely low magnitude. They also agree that disturbances on tower and ground-wire systems usually are limited to approximately six spans, where tower footing resistances are low. Potentials induced on the conductor arising from such surges on the ground wires become nil beyond the region of the disturbance. Thus no surge on the conductor can be propagated beyond this region unless flashover takes place.

In addition to the foregoing, Fortescue and Conwell discuss in some detail the effect of line construction on surges propagated over the lines to substations. It is finally concluded that ordinarily with only one type of construction, namely, ungrounded wood pole, will the potentials be sufficiently high to endanger substation equipment. Pittman and Torok's results agree with the fourth case just described in that voltages of high magnitude may be transmitted for several miles along highly insulated transmission lines and thus appear at terminal apparatus. This is true especially when direct strokes or their branches terminate on line conductors.

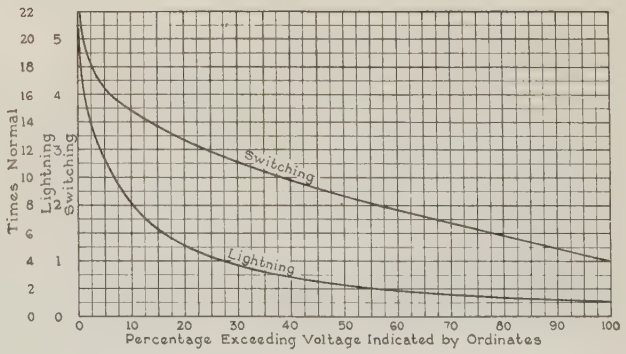


Fig. 20. Surge voltage curves compiled by Lewis and Foust based upon data from fourteen systems for the years 1926-30 inclusive

Ground Wires and Tower Footing Resistance

"That a direct stroke could occur to the line without producing a trip-out" is said by Sporn and Lloyd to be one of the outstanding determinations of the 1930 lightning investigation and is believed to be due to the protection offered by the overhead ground wire in diverting the stroke to ground. In regard to tower footing resistance they continue that "the better showing in Ohio was probably due to the lower average tower ground resistance in Ohio, mostly less than 10 ohms against one-third of more than 50 ohms in New Jersey."

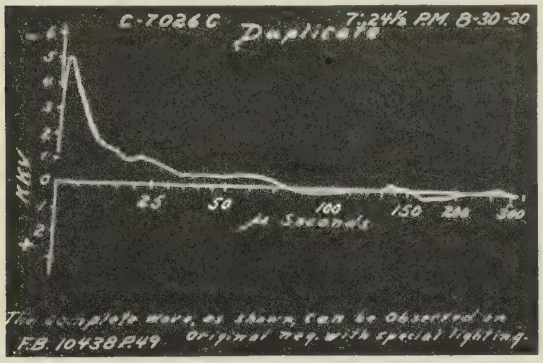


Fig. 21. 5,000-kv. surge measured 4 miles from point of stroke

All three phases flashed to ground splitting the wood-pole supporting structure and causing a circuit breaker operation. Also center conductor flashed 22 ft. to a telephone line at a crossing 3,600 ft. from the stroke

Data obtained in these field investigations have established without question the effectiveness of the conventional ground wire for protecting lines against lightning disturbances. In general it has been found that only in rare cases will a line conductor be struck when steel tower construction with conventional ground wires are used. The results show in addition that from two to three times as many interruptions occur due to lightning on lines without ground wires as occur on lines with ground wires installed.

It is reported by Lewis and Foust that out of 231 total interruptions on the transmission system of the Public Service Electric & Gas Company (New Jersey), only six have occurred on 66- and 132-kv. lines where overhead ground wires are installed. Mention is made also of a 14-mi. 66-kv. double-circuit steel-tower line operated by the Philadelphia Electric Company which is equipped with two ground wires, one placed vertically over each of the outermost conductors. This line has not experienced an outage due to lightning in fourteen years. The beneficial effect of low tower footing resistance also is well emphasized in this case since the resistances are all unusually low and uniform, being of the order of 4 ohms each. In this connection Fortescue and Conwell, speaking of the 220-kv. lines of the Public Service Electric & Gas Company, state that "during one year's investigation on lines equipped with ground wires, no flashovers have occurred where tower footing resistances are less than 5 ohms."

A direct comparison between lines with and without ground wires has been obtained by Bell and Price. This comparison is illustrated in Fig. 22, where the number of flashed insulators per tower per year has been plotted against tower footing resistance for each case. The effect of ground wires appears to be to reduce the number of flashovers to about 15 per cent of those which otherwise would occur. The effect of tower footing resistance at least above 17 ohms seems to be negligible in this case.

Some difference of opinon appears regarding the benefits of low tower footing resistance. It is quite generally agreed, however, that extremely low resistances (only a few ohms) do show a marked beneficial effect.

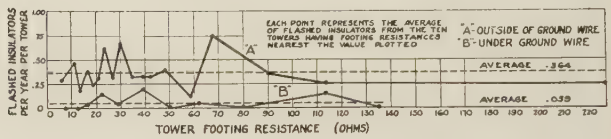


Fig. 22. Effects of tower footing resistance and overhead ground wires on insulator flashovers occurring on a 220-kv. line section

Wave Shapes

According to Lewis and Foust, oscillographic work on transmission lines under natural lightning conditions has shown that waves to be expected on transmission lines vary in time to crest from about 1 microsec. to several hundred, but that the tail of the wave extends over a much wider range. In general the lower voltage surges appear to be of longer time duration.

Wave shapes measured at or near the origin of surges have fronts which bring the conductor potential up to flashover values in the order of about 1 microsec. These high-amplitude waves of steep front usually cause flashovers and therefore are reduced quickly to low potential values. Apparently voltage waves rising to fairly high values, but still under insulator assembly flashover value, would possess a longer time to crest and also a wave tail of at least some 10 to 100 microsec. in length.

Wave fronts rising at the rate of from 1,000 to 2,500 kv. per microsec. have been measured in several cases, but Pittman and Torok in their test on a wood pole line found that surges at the point of origin may have a rate of rise of 4,000 kv. or more per microsec.

Sporn and Lloyd present curves showing approximate wave shapes for the maximum, minimum, and average wavelengths observed on 29 oscillograms recording 50 kv. on crest or higher, and therefore not causing flashovers (see Fig. 23). Wave shapes for higher voltage surges where flashover occurred are shown in other illustrations.

Bell and Price state that among other things the wave forms of lightning surges appear to be dependent upon whether the surge originated and created fault on the phase to which the oscillograph is connected, or on either or both of the other two phases.

Gross and Cox in speaking of attenuation agree that attenuation is greater for positive than for negative surges. They assert further that attenuation of high-voltage surges is very rapid, maximum crest values in

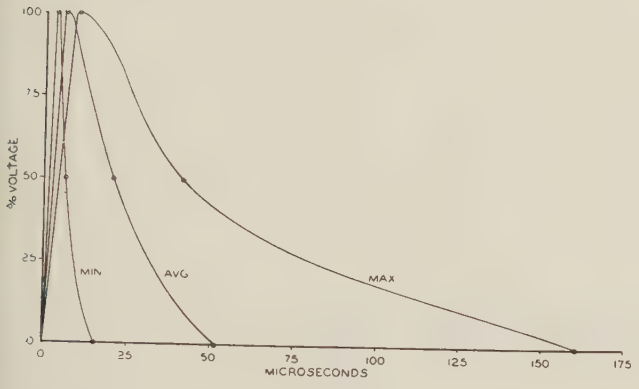


Fig. 23. Empirical wave shapes of lightning surges showing envelopes for maximum, minimum, and average time relations

the order of 2,000 kv. being reduced to one-half that value within about a mile. An empirical formula has been developed from actual measurements by which the voltage reduction or attenuation can be determined for any point on the line. This is illustrated in Fig. 24. This formula contains constants which depend upon the characteristics of the line under consideration, and agrees fairly well with results of attenuation studies where artificial lightning has been used.

Wave shape and attenuation studies of natural lightning discharges in general agree fairly well with the results of theoretical studies outlined previously, but in any case the wave shape of a particular surge appears to depend upon (1) whether the surge results from a direct stroke or is induced, (2) polarity, and (3) whether or not flashover takes place.

Polarity

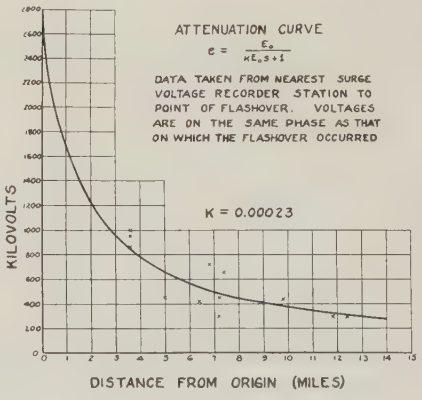
Some difference of opinion exists regarding the polarity of lightning discharges as evidenced by excerpts presented herewith. Bell and Price state that most lightning strokes are of negative polarity, as indicated by measured structure currents. Smaller proportions appear to be oscillatory with negative polarity predominating. Positive surge voltages between conductor and tower usually are indicated at locations where a ground wire or conductor not coupled to the surge voltage recorder is contacted by direct strokes. These therefore are not indications of induced surges due to cloud fields.

Gross and Cox report that 60 per cent of the conductor surges measured by them were negative, 40 per cent positive. Of the ground-wire surge voltages investigated, 70 per cent were positive, 21.5 per cent negative, 8.5 per cent oscillatory.

Sporn and Lloyd found that lightning surges were positive ten times as often as negative, but that each of the stroke recorder charts indicated the cloud to be negative. These authors advance the belief that overhead ground wires prevent the majority of negative lightning bolts from reaching phase wires and that, therefore, positive surges measured on the lines are due to induction.

Lewis and Foust state that measurements of cloud field potentials have established beyond question that fields of both polarities are present, and that field polarity at a point on the ground may change from positive to negative or from negative to positive during storm. Additional statements made by these authors, however, are to the effect that all lightning stroke recorder charts of direct strokes to tower indicate the tower to be negative. From this it is inferred that clouds are negative and the ground positive. With the tower structure positive with respect to the cloud, breakdown proceeds from structure to negative cloud, and the strokes terminate on the grounded structure under this polarity condition. Should the tower structure become negative with respect to clouds, strokes would proceed from the cloud, and the probability of the tower being struck would not be great. While this conception appears to reverse the accepted picture of cloud-to-ground strokes, nevertheless it is said to be consistent by being in accord with laboratory and field experience.

Fig. 24. Attenuation curve and formula determined empirically from surge-voltage recorder data



Protection Against Lightning Surges

Requirements for a "lightning proof" line, where this seems justified economically, are outlined in this article. Insulation alone is not the final answer, only one of several important features of proper line design. A new arrester of the gap type is described also, wherein the breakdown medium is a column of air.

INSULATION FAILURES arising from lightning discharges are shown by experience to be the cause of a majority of transmission line outages. It is highly desirable, therefore, that protective measures be adopted and practical protective devices be installed to reduce the number and seriousness of such disturbances. That it is impractical to over-insulate a line sufficiently to withstand lightning voltages is substantiated by records which show that sometimes even on wood pole lines there are impressed surge potentials of sufficient magnitude to flash over the wooden structures to ground.

Overhead Ground Wires

The effectiveness of conventional overhead ground wires for lightning protection where steel tower construction is used has been well emphasized by the investigations covered in other articles of this group. For ground wires to be most effective, however, according to general consensus of opinion tower footing resistances should not exceed 4 or 5 ohms.

So-called diverting wires have been experimented with on operating lines. These are special ground wires which may or may not be insulated from tower structures, and which generally are located at a greater distance above the line conductors than are the conventional ground wires. One form of diverter-wire construction is shown in Fig. 25; Peek suggests the possible effectiveness of other forms. According to Lewis and Foust, where such wires are supported on the line towers the only advantage appears to be that due to the increased height of these wires whereas when insulated from the tower structure and provided with independent grounds of low resistance, they possess the distinct advantage of keeping lightning currents out of tower structures. Protection offered by conventional ground wires, however, is said to be such

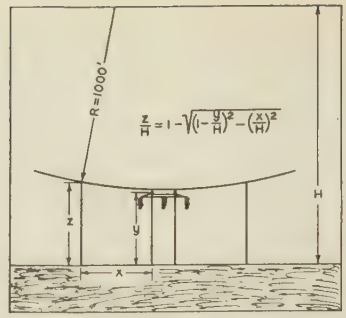


Fig. 25. One type of diverter for lightning protection where high tower footing resistance cannot be avoided. Z represents the minimum height

that only in cases of high tower footing resistances do diverting wires appear feasible.

Tower Grounding and Counterpoises

Where tower footing resistance is too high for efficient ground-wire protection the resistance can be lowered materially by installing buried wires or cables connected directly to the tower legs. These wires may be either extended out radially from the tower or directly from tower to tower along the line. According to Peek radial wires of moderate length usually should be most effective; when installed in this way they are called counterpoises.

Investigations have been made recently to determine the effectiveness of counterpoise in reducing the surge impedance of a tower and thus increasing the effectiveness of the overhead ground wires. On this subject, tests made by Brune and Eaton using artificial lightning discharges revealed valuable information which will be outlined briefly in the following paragraphs.

Theoretically the counterpoise will tend to reduce tower footing voltages both by increasing the capacitance to ground (ground potential assumed to be at an appreciable depth below ground level) and by allowing leakage of charges from towers into the earth. On surge voltages, however, the time element enters in causing the counterpoise to behave like a line with a very high "leakance." Thus reflections may occur from the remote ends of the counterpoise cables and may make themselves felt at the tower footing ends.

For test purposes a tower location was selected where footing resistance measured at 50 cycles was rather high (400 ohms). Various arrangements of counterpoise were connected and surges discharged directly from the line into this grounding system. A probe was driven into the ground about 40 ft. away from the tower and the voltage was measured between that probe and the point at which the line was grounded. In some tests the line was grounded through a known resistance, the voltage across the resistance being taken as a measure of ground current.

Results of the first test are depicted in Fig. 26 where the curves show tower footing voltage for different lengths of counterpoise. As may be noted, extending the counterpoise in two directions produces practically double the effect of extending it in one direction only, but there is no great advantage apparent in extending

it further than 1,000 ft. Since this distance in most cases would be more than a full span length the counterpoise in reality would involve at least two spans. How much shorter than 1,000 ft. the counterpoise may be made and still be effective will depend upon the length of surge to be expected and particularly upon the length of the wave front. Counterpoise can be made much more effective by extending in more than two directions, but right-of-way limitations in most cases would constitute a practical obstacle to this.

Additional tests show that current and voltage relations in a counterpoise are not proportional. This fact emphasizes again the non-constant nature of surge impedance. It has been found also that for long wave-fronts the effectiveness of a counterpoise is greater than for short ones. For a surge of approximately rectangular front such as might arise from a direct stroke to a tower, "leakance" of the counterpoise would have no effect initially; only its resistance functioning to limit the tower voltage. This is of considerable importance since with direct strokes the counterpoise to be effective must lower the tower footing impedance to such a value that the tower potential cannot rise to the flashover point.

Influence of Line Design

The influence of line design constitutes another phase of the lightning situation which has been investigated to some extent. The importance of low surge impedance for the grounded supporting structure of a line has been duly emphasized and needs no further mention here. Certain other features, however, play an important part in determining how a certain line will react toward lightning disturbances.

First and foremost it is important that, if possible, line structures be kept clear of high elevations since lightning has a natural tendency to strike the highest object within its range. Where lines must be run over high ground, trees adjacent to the right-of-way will provide some protection. It is desirable also that span lengths be kept as short as possible so that reflections (which have a tendency to reduce the tail of the wave) will return to the point struck in the shortest possible time and thus tend to shorten the wave.

As previously brought out, where high tower footing resistance cannot be avoided, special overhead ground-wire construction or diverters may be employed. Where the economics of the situation will permit, these may be placed in such a way that they will shield the line from direct lightning strokes.

Peek has devoted a great deal of attention to proper line design as regards lightning protection. From the results of his studies he concludes that a "lightning-proof" line for almost any voltage seems feasible. The general requirements for such a line are (1) low elevation, (2) short spans, (3) low tower footing resistance, (4) ground wires, special ground-wire constructions or lightning diverters where tower footing resistances are high, and (5) highly insulated conductors (using from 14 to 16 disk insulator units as is customary on the present 220-kv. lines).

Lightning Arresters and Gaps

The desirability of lightning arresters for protecting terminal equipment in substations is recognized generally. Lightning arresters also are finding some application on transmission lines, especially where provision for ground wires is not easily made. Arresters possess the distinct advantage of being easily placed at just the points where the protection is desired. Their most distinct disadvantage lies in the fact that

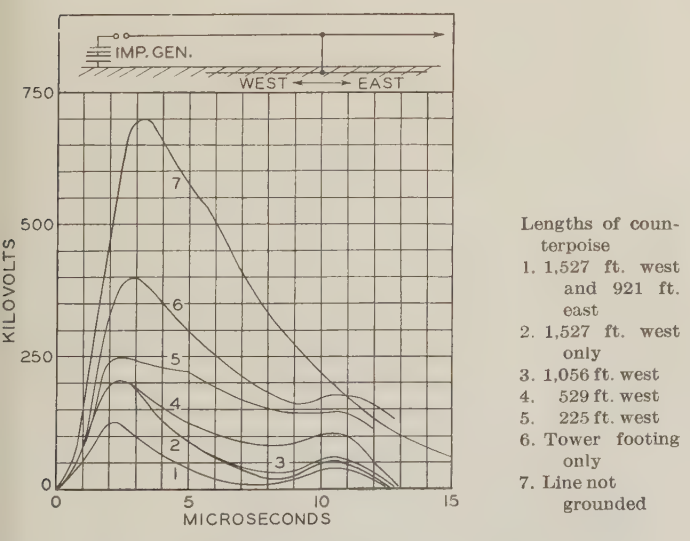


Fig. 26. Surge voltages at point of grounding for various lengths of counterpoise

Fig. 27. Section of air-breakdown expulsion-type lightning arrester

(*a*) Fiber tube (*b*) Arc chamber (*c*) Metal electrode

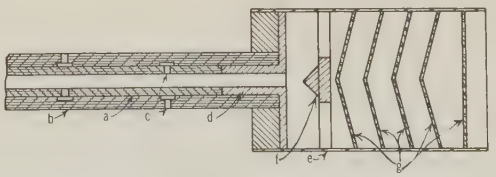


Fig. 28. Section of deionizing chamber for ends of expulsion arrester

(*a*) Inner fiber tube, (*b*) outer fiber tube, (*c*) gas vent, (*d*) electrode, (*e*) steel shell, (*f*) flame spreader, (*g*) perforated baffles

their protective effect does not extend more than 500 ft. from the points of application. This feature may prevent arresters coming into general use on transmission lines.

In general, lightning arresters may be grouped into two classes: (1) those which have valve action, acting as good conductors when the voltage rises to a definite predetermined value and as insulators when the voltage drops below some lower value; and (2) those which become good conductors when the voltage reaches a definite value and continue to pass current until the zero point of the current cycle is reached. Familiar examples of the first class are the so-called Thyrite and oxide-film arresters. Familiar examples of the second type are gap devices, both fused and non-fused, of which there are several designs.

Devices of the latter type, consisting of fused horn-gaps, were in use on the 110-kv. wood pole line on which Pittman and Torok conducted their tests. These devices were expected to discharge current incident to lightning surges, and to interrupt subsequent 60-cycle power currents sufficiently promptly to prevent oil circuit breaker operation. In thirteen distinct operations, each resulting in blown fuses, a total of six flashovers occurred, none of which caused a switch operation. In one case, however, a three-phase short circuit resulted from a 5,000-kv. surge which arose from a direct stroke to the line. Details of this event appear elsewhere in this symposium (see Fig. 21). All three fuses in the nearest horn-gap device (about one-half mile away) were found blown, but this did not prevent a switch operation. These results support the previous statement that the protective effect of such a drain point does not extend very far beyond the point of application, even where lines are as highly insulated as this one. Moreover a single fuse seemed inadequate because many flashes of lightning are made up of several successive discharges following each other at very short time intervals, and because after a single fuse has blown no protection is afforded against additional strokes.

A multiple-fuse device accordingly was installed at six locations providing three fuses so arranged that they would blow successively upon the occurrence of lightning surges of sufficient magnitude to cause the gap to flash over. Results were fairly satisfactory, but the necessary continuous patroling and replacement made the arrangement unattractive economically.

An Insulator Protector

An expulsion type of arrester then was developed consisting essentially of a fiber tube 38 in. long with a wire electrode in each end to reduce the effective arcing length to 30 in., insuring breakdown within the tube. This device was inserted without additional gaps into the line hardware grounding lead. Although these devices have been in use only a comparatively short time they have proved quite satisfactory; eight successful operations have been recorded.

Torok describes in detail some of the difficulties encountered in the development of this device. Some difficulty was encountered in devising assemblies in which breakdown within the tube could be assured. A most promising arrangement was found to be that in which the ratio of internal to external spacing was not greater than 0.85 (see Fig. 27). Some difficulty was experienced also in obtaining proper wall thickness of the tube, since repeated flashovers sometimes caused tube breakdown either by splitting or by puncturing.

In regard to its interrupting characteristics, Torok explains that with an arc established in a cylindrical hole a much higher voltage may be interrupted than if the arc is drawn in the open. If the hole is too small, however, only relatively small currents can be discharged through it. Slepian has shown that the effectiveness of a confining chamber can be increased many times by the use of a material which will produce a gas. With such material the heat of the arc volatilizes the surface of the walls at a rapid rate forcing into the arc stream an appreciable quantity of un-ionized gas. This gas greatly raises the arc voltage and the voltage which can be interrupted. In experimental installations the pressure developed within the tubes by the evolution of gas introduced mechanical difficulties which had to be overcome.

Deionizing Principles Applied

In addition to the mechanical difficulties involved, these tubes often flashed over on the outside because of the convection of ionized gases arising from sparkovers. Deionizing chambers attached to the ends of the tubes have been successful in controlling this condition. The deion principles already have been widely described; the mechanics of this particular application are indicated in Fig. 28.

In designing this tube-type arrester for use on any particular voltage it is essential that the impulse breakdown of the tube be lower than the flashover voltage of the line insulation. Since the breakdown voltage of the tube is governed almost entirely by its length, the maximum internal separation of the electrodes is definitely fixed. The design problem then devolves into one of providing the tube strength required to interrupt arcs normally maintained by the system voltage. For low-voltage protection the design becomes more simple since tube lengths are short and the internal diameters can be reduced without creating dangerously high pressures.

Although still in the experimental stage, development work on this insulator protector is being pushed forward rapidly. It is expected that a practical device which is simple in construction, easy to install, and capable of repeated operation without attention eventually will result.

Lightning versus System Operation

Operating experiences form the final proving ground of the many theories developed; the efficiency of any scheme of protection may be ascertained accordingly. Although one overhead ground wire already is known to be highly beneficial, two are shown to be unquestionably better. Opinions conflict as to the effect of tower footing resistance.

ACCORDING to Sporn's previously ıentioned division of the lightning problem as it ffects the operation of electric systems, the third part onsists of practical operating records covering actual perating experiences where devices and designs for ıe mitigation of lightning damage are in use. This eld experience properly analyzed and interpreted ves the final answer as to the tenability of the many ieories developed in connection with lightning and s to the practicability of methods or structures evised to eliminate harmful lightning effects.

Of necessity some of the previous sections of this mposiac have included material which can be classed s operating results. It would be difficult for instance o separate out such results obtained in field investigaons of natural lightning where these have been carried ı with the lines in operation. Sporn, however, has resented the results of a study made entirely upon the asis of operating records and data and has arrived at ertain conclusions based upon the analysis and correlaon of those data. This study is a continuation of milar studies made on the transmission system of the merican Gas and Electric Company; the data, which ere collected in 1929, have been analyzed in the light previous experiences.

The transmission systems studied have been deribed in detail in previously published articles. With ıe exception of a few recent additions the system now mprises 1,198 mi. of 132-kv. lines involving a total of 825 circuit miles. It extends from the southern tip Lake Michigan, southeasterly across the country to northern North Carolina, covering parts of ten ates. With one minor exception all lines within the nge of observation are of double-circuit steel tower nstruction with conductors in vertical configuration; utilize A. C. S. R. conductors, (with a single ground re of the same material) supported by ten disk units suspension and twelve on dead ends. Practically all lines are equipped with some sort of arcing protection for insulator strings.

During 1929, 652 observed storms were reported by stations scattered throughout the system. Of these some 565 occurred during the period from April to August inclusive. Recorded lightning outages for the entire system amounted to 133 in 1928 and 248 in 1929. The increase, while due partly to an increase in miles of transmission lines, is attributed largely to the more severe lightning storms which occurred in the region during 1929. A thorough analysis of the operating records and experiences made and interpreted in the light of previous lightning experience on the same system can be summarized as follows:

Summary of Sporn's Results

1. Two-circuit lines are better than single-circuit lines.

When installed in vertical configuration on the same towers, the use of two-circuit lines enhances system reliability to proportions greater than does the mere doubling of the circuits. Experience indicates definitely that only from 16 to 29.5 per cent of the trip-outs involve both circuits, and it is likely that this percentage can be reduced by higher speed switching.

2. One ground wire is good; two are better.

The only line equipped with two ground wires had 3.6 outages per 100 mi. of line per year; the only line not equipped with a ground wire had an outage record of 75. A line operating in 1929 with one ground wire had 37.4 outages per 100 mi. of line per year; operating in 1928 with no ground wire this line had the 1929 equivalent of 59.3 outages per 100 mi. of line. This clearly shows the benefits of one ground wire, and definitely indicates that two ground wires are more beneficial than one.

3. Grading shields protect insulators only.

Grading shields have little effect on the lightning outages of these 132-kv. lines; but they definitely limit the damage to insulators and conductors, and reduce the amount of cascading required. Over the entire system (most of the system being equipped with grading shields) 23 per cent of the total number of tower flashovers occurred on cascaded strings. The lines on which grading shields were installed recorded only 21 per cent; lines with no shields, 70 per cent. This is a striking indication of the benefit rendered by grading shields.

4. Misleading conclusions may be drawn.

No interpretation of performance of lines under lightning conditions is possible or of real value without an accompanying record of lightning-storm conditions during the particular time discussed. Otherwise, conclusions gravely misleading may be reached.

5. Only one conductor usually involved.

Records of physical inspection and relay-target indications show that in from 4.7 to 5.8 per cent of trip-out cases due to lightning, all three phases are involved; in from 44.2 to 45.2 per cent, the top and middle conductors only are involved; in from 42.8 to 44.3 per cent the bottom and middle conductors are involved; and in from 73.2 to 64.2 per cent one phase only is involved. This analysis strongly indicates that both direct and induced strokes are of vital importance in the performance of this 132-kv. network.

6. Effect of tower footing resistance problematic.

Detailed data on the tower footing resistances on four 132-kv. lines show no tendency for lightning flashovers to concentrate on towers of high footing resistance in preference to those having low footing resistance. In fact, from these data, whether lightning strikes a tower with low or with high footing resistance seems to be a matter of chance. Flashed-over towers were observed to have footing resistances ranging from 1.5 to more than 250 ohms; and 65 per cent of all recorded flashovers occurred at towers having footing resistances of 20 ohms or less while less than 8 per cent occurred where this resistance was 80 ohms or more.

In general there is close agreement between these conclusions and those arrived at on the basis of the

special field investigations. By way of comparison, however, it seems pertinent to mention the following points:

It is generally agreed that efficient ground-wire protection will reduce greatly the number of line outages due to lightning. Bell and Price have found in addition that a counterpoise greatly improves the efficiency of ground-wire protection and thus provides an additional factor of safety, especially where tower footing resistances are high. Fortescue and Conwell state that ground-wire protection near stations should be especially good in order that station equipment (which usually is not as highly insulated as the lines) be provided with the greatest possible amount of protection.

In regard to induced surges versus those caused by direct hits, Bell and Price believe that only in rare cases are induced voltages of sufficient magnitude to cause flashovers on 220-kv. lines. Pittman and Torok in speaking of wood pole lines also state that voltages dangerous to line insulation and equipment in most cases are set up only by direct hits.

There seems to be some disparity in regard to the effectiveness of low tower footing resistance. Fortescue and Conwell report no flashovers on lines equipped with ground wires where footing resistances were less than 5 ohms. Lewis and Foust support this view by calling attention to a 14-mi. 66-kv. double-circuit steel tower line of the Philadelphia Electric Company which has not suffered a lightning interruption for 14 years. This particular line has tower footing resistances of about 4 ohms each and is equipped with two overhead ground wires. Gross and Cox state definitely that an attempt to relate line flashovers to tower footing resistances proved futile while Bell and Price say that the effect of footing resistances higher than 17 ohms seems to be negligible.

Single Patent Appeal Court is Proposed

By
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On the basis of long practical experience the author condemns the present procedure in patent litigation and outlines the foundation for a proposed single United States Court of Patent Appeals which would be second only to the U. S. Supreme Court and would abolish the duplicate and conflicting efforts of the ten district courts in patent matters. Full text of a proposed House of Representatives bill is given.

BECAUSE of the peculiar nature of the patent monopoly, the present system of appeals in patent infringement suits in the United States is the most inefficient, expensive and wasteful to be found anywhere. It is a deterent to the production of inventions, and to the investment of capital in patents. Correction of this condition is by far the greatest need of our patent system.

Present System—Nature and Defects

For the first century of our patent system, there was a single court of patent appeals, the Supreme Court of the United States. This court became so overburdened with work that, in 1891, the appeal to the supreme court was taken away; and the country was divided into nine circuits (now ten), each of which was provided with a circuit court of appeals, having final and supreme jurisdiction of all patent appeals in its circuit.

These courts are independent of each other. While, under the doctrine of comity and unless they see substantial reasons for not doing so, they follow a previous decision by the court of appeals of another circuit on the same patent, they are at liberty to decide oppositely and frequently do so.

As stated, there is no appeal to the supreme court except that of petitioning that court to grant a writ of certiorari ordering the case to be sent up to it. The supreme court has such an enormous volume of work that it does not take up a patent case unless there is some question of public importance, of interpretation of law, or unless two circuit courts have decided the same question concerning the same patent in opposite ways. The decision of a single circuit court of appeals is final in most branches of the law (practi-

Essentially complete text from a pamphlet released May 25, 1931, by Edwin J. Prindle, chairman of the American Engineering Council's patent committee, 111 Broadway, New York, N. Y.

ally the only other exceptions being copyright and rade-mark matters). This is not so as to patents.

The monopoly which a patent grants is a negative ne. The patentee is not granted the right, himself, o make, use or sell the patented invention—a *positive* nonopoly. He already has that right because of his nventorship, unless in doing so he would have to se that which has already been patented to another. The patent merely grants him the *negative* right to xclude all others throughout the United States, from naking, using and selling the patented invention. To be of any value to him, his monopoly must be naintained inviolate. If there is one infringer anywhere in the United States who has been rendered mmune from the patent by a final decision, it will reatly impair and may largely destroy the value of he patent. One hole that cannot be stopped may ink a ship.

Under these circumstances, to make it necessary that he patent shall have been adjudicated oppositely in wo separate circuit courts of appeal before the mere ight shall exist to petition the one court which can ender a final decision, the supreme court, to take it p is a shocking economic waste. A patent may be valid in one circuit and invalid in another. It may ave been given a broad, inclusive, interpretation in ne circuit, and a narrow one in another. It may be nfringed by a given construction in one circuit, and ot infringed by the same construction in another. A defendant in whose favor a patent in one circuit has een held invalid, or not infringed, is free to make, se, and sell in every other circuit; the patentee cannot ven enjoin his agents or customers. Thus, in a single ircuit, a patent may be invalid as to one person or orporation and valid as to everyone else, or *vice versa*. Even if a patent has been sustained in two circuits, here still are eight circuits, any one of which could lecide to the contrary.

If the first of two decisions by a different circuit court f appeals is against a patent, and the supreme court lecides in favor of the patent, it almost invariably is oo late for the decision of the supreme court to affect he first case; and the defendant in that case is free o infringe the patent throughout the remainder of ts life and throughout the whole country. Furthermore, the statute provides that where the patent overs more than the patentee invented he must, with easonable promptness, file a disclaimer in the U. S. Patent Office disclaiming that which is not his invention. Where in the first suit under the patent a court f appeals holds a claim to be invalid, it must promptly e disclaimed under penalty of the patentee losing the ight to bring other suits under the patent. The law rovides that the disclaimer becomes a part of the atent, and is effective throughout the United States n all circuits. Thus patents may be nullified rretrievably because of a plurality of courts of appeals. With a single Court of Patent Appeals, the validity of the claims could be finally determined before any disclaimer was filed. Moreover, by the time the patentee has obtained a favorable decision in a second circuit in any of these cases, much of the short life of the patent (seventeen years) usually has expired with no substantial reward to the inventor. Expenses of these repeated litigations make them impossible to the individual, and constitute a burden from which even large corporations shrink.

With ten courts of appeals there are unavoidable differences of opinion on various points of law and differences of tradition as to the liberality or strictness of construction to be applied to a patent under the same circumstances. Under a single court of patent appeals the administration of the patent law would attain completeness and certainty and uniformity of application now lacking in these and other respects. Patents also involve many difficult questions of science and engineering, upon which judges may and often do differ. Thus it is impossible for the decisions of various circuit courts of appeals on the same patent always to be uniform.

Quite as many adjudicated patents are held to be invalid as are sustained. Both the public and the patentee, therefore, need to know early in the life of the patent whether or not the patent is valid, and what is its scope. If the patent is invalid the public should know it through a single final decision, and not be kept in uncertainty for years during which it would have been free to use the alleged invention described in the patent. However, if a patent is valid, the patentee early in the life of his patent should have a single decision which applies throughout the United States and which would hold against all subsequent defendants, unless they set up defenses substantially different from those considered in the first suit, or unless they use a structure outside the monopoly of the patent as determined in the first suit.

The patent should be adjudged as to validity, scope and infringement, on the same principles and policy throughout the United States, both for the sake of the public and the patentee. The head of the patent department of one of the largest corporations in this country said to the writer recently, "Whether a patent is valid or invalid, we want, early in its life, to know definitely so that we may shape our course accordingly and with confidence that the situation will not be changed during the life of the patent, except for substantial reasons."

The only solution of the difficulty is a "single court of patent appeals."

History of Legislative Efforts

In 1903 the American Bar Association approved the principle of a report of its patent committee recommending the establishment of a single court of patent

appeals, and directed that committee to lay a bill for that purpose before Congress. The particular bill then proposed was not approved, but the principle of a single court of patent appeals was approved, leaving the form of the bill open. Mr. Frederick P. Fish was chairman of the patent section, and vigorously advocated the bill, which provided for a chief justice, appointed for life, and six judges chosen from the circuit and district courts to sit for terms of six years each.

Both the 1903 attempt and a subsequent attempt made in 1919 failed, however. The House Committee refused to approve the bill because it became apparent that judges would not break up their homes and interrupt their friendships and their children's schooling and go to Washington merely for a term of six or possibly twelve years. It became clear that appointments would have to be permanent to induce judges to become members of the proposed court.

Meanwhile, the need for a single court of patent appeals has been growing constantly. Such a court is now a practical necessity. It would substantially stimulate inventing and would protect both the patentee and the public from enormous unnecessary expense.

The American Engineering Council recently has approved renewing the legislative effort with a bill curing the former objections. The National Association of Manufacturers again has passed a resolution approving of the principle of a single court of patent appeals, and the undertaking of another campaign at this time to enact a bill for the purpose. Also, various committees of patent law associations are considering the advisability of a renewed effort to secure a single court of patent appeals.

Provisions of Proposed Bill

The writer has prepared a bill which provides for a single court of patent appeals sitting at Washington, and composed of a chief justice and six associate judges, five of the seven judges to constitute a quorum. Not only the chief justice, but the associate judges are to be appointed, as the Constitution says, "during good behavior." The proposed court is to have final jurisdiction of all appeals in patent cases from the District Courts of the United States and from the Supreme Court of the District of Columbia, both in interlocutory and final orders and decrees, jurisdiction of the United States Circuit Courts of Appeals in patent appeals being abolished. The power of the Supreme Court of the United States to order cases certified to it, is extended to include the proposed single court of patent appeals, and the right is given to that court to certify questions to the Supreme Court for instructions.

Salaries of the chief justice and the associate judges of the single court of patent appeals as proposed are $13,500 for the chief justice, and $13,000 for the associate judges. These are higher than those of the circuit courts of appeals, thereby ranking the single court of patent appeals next to the Supreme Court of the United States. This undoubtedly would assure that a sufficient number of the best qualified judges in patent cases will be available for appointment to the proposed court.

That the judges shall be specially qualified for the adjudication of patent cases in the single court of patent appeals, the bill provides that "experience in the adjudication of a substantial number of patent cases on the federal bench, or in the practise of patent law in the federal courts, shall be requisite to appointment as chief justice or a judge of said court, to the end that only judges who have shown special aptitude for the adjudication or the practise of the patent law shall be appointed to said court." Further experience and observation show that, by the adjudication of many patent cases, they would acquire a facility for comprehending the science and engineering of patent cases which would enable them, to a much greater extent, to make a selection on their own judgment between the conflicting opinions of experts.

The proposed bill changes the name of the court of customs and patent appeals to the "court of customs and patent office appeals," and it does not provide for appeals therefrom to the single court of patent appeals. However, an applicant for a patent (in every case except where the commissioner of patents is a necessary party, instead of appealing from the commissioner of patents to the court of customs and patent appeals) could reach the proposed single court of patent appeals by appeal on a bill in equity filed in the Supreme Court of the District of Columbia or, where the opposing party in the interference is not a resident of the District of Columbia, by an appeal on a bill filed in the district court of the district of which his opponent is a resident.

The establishment of a United States Court of Patent Appeals not only would be a great benefit to patentees and to the public, but will increase the effectiveness of patents, and prolong the productive portion of their terms. It would also substantially stimulate inventiveness and the building of businesses under patents. Establishment of the U. S. Court of Customs Appeals (now the U. S. Court of Customs and Patent [Office] Appeals) affords a precedent for the establishment of a single U. S. Court of Patent Appeals.

It is believed to be entirely possible to secure the establishment of a single court of patent appeals at this time if sufficient support is given by those who realize the importance of the patent system to the United States.

Attention is invited to the following draft of the proposed bill for a single court of patent appeals, the principal provisions of which have just been outlined.

Complete Text of Proposed H. R. Bill

IN THE HOUSE OF REPRESENTATIVES

A BILL

o Establish a Single United States Court of Patent Appeals, To Change the Name of the United States Court of Customs and Patent Appeals, and for Other Purposes

Be it enacted by the Senate and House of Representatives of the United tates of America in Congress assembled, that there is hereby created an nited States Court of Patent Appeals, which shall consist of seven ustices, of whom five shall constitute a quorum, and shall be a court of ecord with jurisdiction as is hereinafter limited and established. Such ourt shall prescribe the form and style of its seal and the forms of its writs nd other process and procedure as may be conformable to the exercise of s jurisdiction as shall be conferred by law. It shall have the appointment f the marshal of the court, who shall have the same powers and perform ie same duties under the regulations of the court as are now provided or the marshal of the Supreme Court of the United States, so far as the ame may be applicable. The Court shall also appoint a clerk, who shall ave the same powers and perform the same duties now possessed and performed by the clerk of the Supreme Court of the United States, so far as the ame may be applicable. The salary of the marshal of the court shall be 3,500. a year, and the salary of the clerk shall be $5,000. a year, both to be aid monthly in twelve equal payments. The costs and fees now provided y law in the Supreme Court of the United States shall be the costs and fees i the United States Court of Patent Appeals: and the same shall be collected, expended, accounted for, and paid over to the Treasury Department f the United States in the same manner as is provided by law in respect o the costs and fees in the Supreme Court of the United States. The Court hall have power to establish all needful rules and regulations for the conuct of its business within its jurisdiction as conferred by law.

Sec. 2. That the President of the United States, by and with the advice nd consent of the Senate, shall appoint a chief justice, and six associate ustices of said United States Court of Patent Appeals, and as vacancies ccur shall in like manner appoint others to fill such vacancies from time to me. The acceptance of one of said offices by a circuit or district judge of ie United States shall vacate his office as circuit or district judge. Experience in the adjudication of a substantial number of patent cases on the ederal bench or in the practice of the patent law in the Federal courts shall e requisite to appointment as chief justice or an associate justice of said ourt, to the end that only judges who have shown special aptitude for the djudication or the practice of the patent law shall be appointed to said ourt. Appointment to said court shall be during good behavior.

Sec. 3. That a term of the United States Court of Patent Appeals shall e held annually at the City of Washington, beginning on the second uesday of October in each year, and the same may be adjourned from time o time as the court shall order. If at any time for the meeting of the court quorum of the justices shall not be present, the justices present may adourn the court and, if necessary, adjourn again from time to time until quorum appear. If at any sitting of the Court, the Chief Justice shall be bsent, the associate justice senior in commission as a circuit judge, or enior in age in case of commissions of even date, shall preside. If no assoiate justice who has been a circuit judge shall be present, the associate ustice senior in commission as a district judge shall preside. In case of ommissions of even date, the justice who is senior in age shall preside. pon a request of the Chief Justice, or a presiding associate justice of The ourt of Patent Appeals, the Chief Justice of the United States shall desigate a judge, or judges, of any federal court to fill a temporary vacancy in ie said Court of Patent Appeals. Until it shall otherwise be provided by ongress, the sessions of the court shall be held in a building or rooms to be rovided by the marshal of the District of Columbia, under the direction nd approval of the Attorney General of the United States. The court shall y order authorize its marshal to employ such deputies and assistants for imself and the clerk of the court and such criers, bailiffs, and messengers s the business of the Court shall require, and to pay the salaries of such nployees at rates of compensation not exceeding those paid for similar rvices in the Supreme Court of the United States, and to pay all other ecessary incidental expenses of the court. The Chief Justice and each of ie Associate Justices shall be entitled to employ a clerk, whose salary, at rate not exceeding that allowed the clerks of the Chief Justice and assoiate justices of the Supreme Court, shall be paid as part of the expenses of ie Court. The Court shall have power, in its discretion, to appoint a porter and to fix by order his salary or other compensation and direct ie form and manner of the official publication of its decisions.

Sec. 4. That the Chief Justice of the United States Court of Patent ppeals shall receive a salary of $13,500. per year. The Associate Justices the said court shall each receive a salary of $13,000. per annum. All the id salaries shall be payable in twelve equal monthly installments. The me during which any Justice shall serve in said court shall be deemed conuuous service with that in any other court of the United States, before or ter such service within the meaning and intent of Section Three Hundred d Seventy-five of title Twenty-eight of the United States Code.

Sec. 5. That the United States Court of Patent Appeals shall have jurisdiction to hear and determine appeals from final judgments and decrees in the district courts of the United States and in the Supreme Court of the District of Columbia in cases arising under the laws of the United States relating to patents for inventions, and from final judgments and decrees in cases arising under the laws of the United States relating to patents for inventions rendered by any other court having jurisdiction under the laws of the United States to hear and decide such cases in the first instance: Provided, however, that it shall have no jurisdiction of cases originating in the Court of Claims nor of cases in which the Commissioner of Patents is a necessary party. All such appeals shall be taken within three months after the entry of the order, judgment, or decree sought to be reviewed. The practice, procedure, and forms to be observed in the taking, hearing and determination of such appeals shall conform to the practice, procedure, and forms observed in like cases in the Supreme Court of the United States, subject to such rules and regulations as shall be prescribed by the Court. The said Court shall have power to prescribe the forms of records on appeals thereto.

Sec. 6. That whenever, by an interlocutory order or decree in a district court of the United States, in the Supreme Court of the District of Columbia or other Court having jurisdiction under the laws of the United States to hear and decide in the first instance cases arising under the patent laws, in a case in which an appeal may be taken from the final decree of such court to the United States Court of Patent Appeals, an injunction or restraining order shall be granted, or refused, or continued, or vacated, or modified, or retained without modification after motion to modify the same, an appeal may be taken from such order or decree by the party aggrieved to the United States Court of Patent Appeals: Provided, That the appeal must be taken within thirty days from the service of notice of entry of such order or decree; and it shall take precedence in the appellate Court; and the proceedings in other respects in the court below shall not be stayed unless otherwise ordered by that court, or the United States Court of Patent Appeals, or a judge thereof, during the pendency of such appeal.

Sec. 7. That the chief justice and the associate justices of the United States Court of Patent Appeals shall each exercise the same powers in term and vacation in the allowance of appeals, supersedeas orders, and other matters incidental to the jurisdiction and business of the Court as are now exercised by the Chief Justice and associate justices of the Supreme Court of the United States in relation to the business and jurisdiction of that Court.

Sec. 8. That the decisions of the United States Court of Patent Appeals in all cases within its appellate jurisdiction shall be final, except that it shall be competent, as hereinafter provided for the Supreme Court of the United States to require, by certiorari, or otherwise, any such case to be certified to it for its review and determination with the same power and authority in the case as though it had been carried by appeal from the trial court directly to the Supreme Court.

Sec. 9. That whenever any case shall have been certified from the United States Court of Patent Appeals to the Supreme Court of the United States, by certiorari or otherwise, it shall, upon its determination by the Supreme Court, be remanded to the district court of the United States or other court in which it originated for further proceedings to be taken in pursuance of such determination. And in every case determined by the United States Court of Patent Appeals upon appeal, the case shall be remanded to the District Court of the United States or other Court from whence it came, for further proceedings to be taken in pursuance of such determination.

Sec. 10. That all appeals in cases in which appellate jurisdiction is by this Act conferred upon the United States Court of Patent Appeals which shall have been pending without hearing in the United States Circuit Courts of Appeals or other court of appellate jurisdiction for less than three calendar months prior to the taking effect of this Act shall be transferred from such circuit courts of appeals or other courts to the United States Court of Patent Appeals and be heard and determined in that court as though they had been taken there from the trial courts by appeal without further payment for certifying the record or any new or additional docket or calendar fee; all other appeals and writs of error in cases in which appellate jurisdiction is by this Act conferred upon the United States Court of Patent Appeals which shall be pending in the United States circuit courts of appeals or other courts of appellate jurisdiction at the time of the taking effect of this Act shall remain and be heard and determined by the courts in which they may be pending, respectively, as though this Act had not been passed.

Sec. 11. That after the taking effect of this Act no appeal shall be taken from any district court or from the Supreme Court of the District of Columbia or other Court of the United States to any United States circuit court of appeals or other appellate court in any case in which an appeal may be taken to The United States Court of Patent Appeals under the provisions of this Act. If, in any case, it is found that no substantial question under the patent laws is raised by the appeal, the court may order that such appeal be sent to the circuit court of appeals having jurisdiction over the district in which the suit was brought, or the Court of Appeals of the District

of Columbia, as the case may be; if any appeal shall be taken to any circuit court of appeals, or to the Court of Appeals of the District of Columbia, and such court shall find that such appeal involves a question arising under the patent laws of the United States, except in a case where the Commissioner of Patents is a necessary party, such court shall order such appeal to be sent to the Court of Patent Appeals, and no appeal shall be dismissed solely on the ground that the appeal has been taken to the wrong court.

Sec. 12. Section 301a of Title 28 of the United States Code is hereby amended to read as follows:

> The title of the United States Court of Customs and Patent Appeals, created by Section 301 of this title, is hereby changed to The United States Court of Customs and Patent Office Appeals.

Sec. 13. Section 346 of Title 28 of the United States Code is hereby amended to read as follows:

> In any case, civil, or criminal, in The United States Court of Patent Appeals, in a Circuit Court of Appeals, or in the Court of Appeals of the District of Columbia, the Court may at any time certify to the Supreme Court of the United States any questions or propositions of law concerning which instructions are desired for the proper decision of the cause; and thereupon the Supreme Court may either give binding instructions on the questions and propositions certified or may require that the entire record in the cause be sent up for its consideration and thereupon shall decide the whole matter in controversy in the same manner as if it had been brought there by writ of error or appeal.

Sec. 14. Paragraph (a) of Section 347, Title 28 of the United States Code is hereby amended to read as follows:

> (a) In any case, civil or criminal, in a circuit court of appeals, or in the United States Court of Patent Appeals, or in the Court of Appeals of the District of Columbia, it shall be competent for the Supreme Court of the United States, upon the petition of any party thereto, whether Government or other litigant, to require by certiorari, either before or after a judgment or decree by such lower court, that the cause be certified to the Supreme Court for determination by it with the same power and authority, and with like effect, as if the cause had been brought there by unrestricted writ of error or appeal.

Sec. 15. That Sec. 377, Title 28 of the United States Code, be amended to read as follows:

> "Power to issue writs. The Supreme Court, and the District Courts shall have power to issue writs of *scire facias*. The Supreme Court, the Court of Patent Appeals, the Circuit Courts of Appeals, and the District Courts shall have power to issue all writs not specifically provided for by statute, which may be necessary for the exercise of their respective jurisdictions and agreeable to the usages and principles of law."

Sec. 16. That all laws and parts of laws inconsistent with the provisions of this Act are hereby repealed.

Sec. 17. That this Act shall take effect and be in force on the day of nineteen hundred and

Twin Motors for Heavy Rolling Mills

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Twin-motor drive has met effectually the repeated demands for more power at the rolls. Other advantages, however, which now far overshadow the improvement originally sought are the direct outcome of the reduced inertia and greater operating flexibility inherent in this type of drive.

TWIN-MOTOR DRIVE for heavy blooming and slabbing mills has grown out of an increasing demand for power at the rolls greater than can be provided conveniently by conventional design methods. At the same time, this new development is a logical step in the modern trend toward greater mechanical simplicity in rolling-mill machinery. Already two machines, one a 54-in. blooming mill, the other a 44-in. slabbing mill, each with main rolls driven by independent motors, are in successful operation.

From "Twin-Motor Drive," presented at the convention of the Association of Iron and Steel Electrical Engineers, Cleveland, Ohio, June 15-19, 1931. A. I. & S. E. E. headquarters, 1010 Empire Bldg., Pittsburgh, Pa.; J. F. Kelly, managing director.

The principal advantages which these installations have exhibited can be summarized as follows:

1. Greatly increased motor capacity may be applied to a single pair of rolls.
2. Pinion losses with their attendant repair and maintenance are eliminated.
3. Twin motors may be designed to have greatly reduced inertia. This means less strain on equipment, more torque available for useful work, reduced motor and generator heating, and greater acceleration.
4. Roll chatter and spindle vibration are practically eliminated.
5. Higher rolling speeds can be maintained and mill tonnage can be increased.

The term "twin-motor" has come to refer to a form of rolling-mill drive in which each of a pair of rolls is independently driven by a separate motor. In a true twin-motor drive the motors may not operate at exactly the same speed at all times; nor do they depend entirely upon the coupling effect of the metal being rolled to maintain correct load division and speed relations.

Independent drive for the working rolls has been used previously in wheel and tire mills, piercing mills, and tube expanders and reelers. In these installations the motors rotated in one direction only at practically constant speed, the metal between the rolls providing an

ective coupling and rather definitely fixing the speed d load relations. Reversing-beam mills with inde-ndently driven edging rolls also were in successful eration. Here experience demonstrated that the speed ations of two reversing motors working on the same ce of steel could be adjusted to take care of vary-drafts with no indication of unusual roll slippage.

When the electrical equipment for the 54-in. blooming

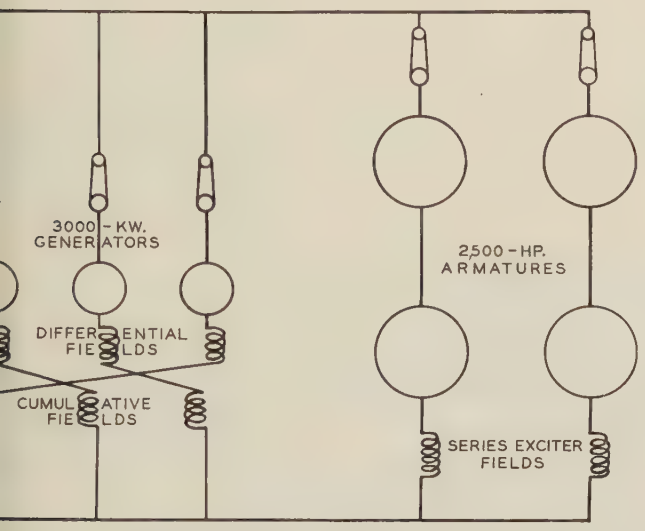


Fig. 1. Main connection diagram for 10,000-hp. twin-motor drive and associated generators

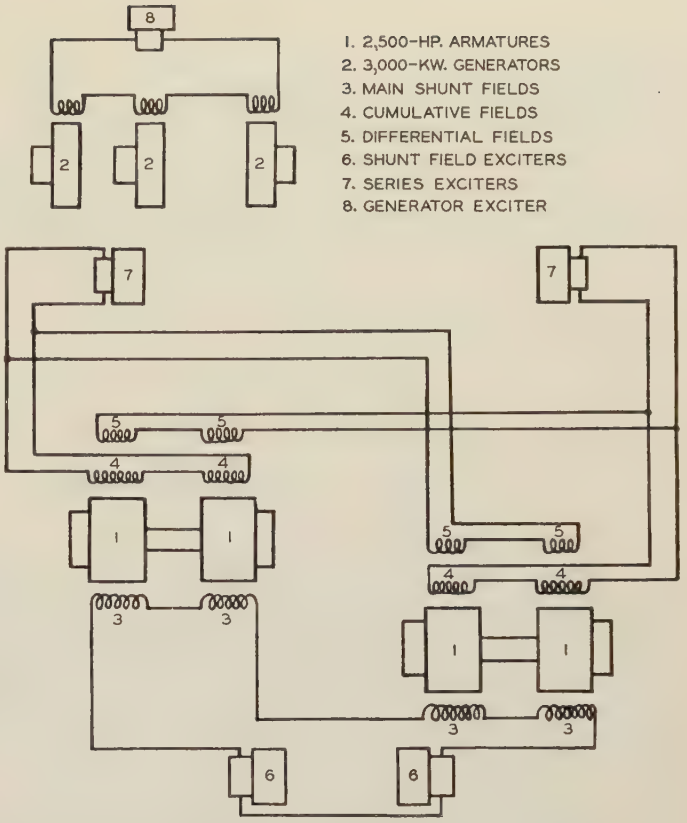


Fig. 2. Field-circuit connections for 10,000-hp. twin-motor drive

ll first was considered it was felt that, to provide wer for rolling heavier sections at higher tonnage es, the continuous capacity and maximum torque of e reversing motor should be greater than had been ed previously.

Accordingly both 10,000- and 12,000-hp. equipments h maximum torques of 3,940,000 and 4,725,000 lb-ft. pectively were considered, since a duplicate mill eady had been built with an 8,000-hp., 50-r. p. m. ve having a rated maximum torque of 2,500,000 ft. It was thought then that for the higher motor ques the drive for the new mill could be improved chanically by eliminating the mill pinions. This chanical improvement now has been realized but er advantages as outlined in the beginning so far weigh those expected that what previously were sidered foremost, now seem insignificant. This, course, is the usual story of many new developments.

Design Difficulties Involved

Design of reversing equipments for machines of this e presents some interesting problems. A motor h a single-unit armature would have the advantages simplicity and comparatively high efficiency. How-r, the maximum capacity which so far has been built o a single-unit armature is 8,000 hp. at 40 r. p. m., l a motor of this size has an armature which ap-aches the largest that can be shipped in one piece. Using present design proportions, about 10,000 hp. continuous capacity at 40 r. p. m. with 3,300,000 lb-ft. maximum torque would be the largest motor which could be built with a single-unit armature. The inertia of such a motor, however, would be tremendously high—in fact about 2.3 times that of the 10,000 hp. twin-motor drive finally adopted.

A double-armature motor offers the next best possibility for a single machine of 10,000- or 12,000-hp. capacity at a speed of the order of 40 r. p. m., but even in this type of machine, the inertia would be nearly twice that of an equivalent twin-motor drive. Construction of the electrical equipment for high-capacity reversing drives thus obviously is somewhat more complex than for small and medium ratings.

In addition to the disadvantages of large single-motor drives already mentioned, pinion stands suitable for transmitting torques of from 4,000,000 to 5,000,000 lb-ft. become extremely large and heavy and their design and manufacture involve serious mechanical problems. For large mills, therefore, the twin-motor drive offers both mechanical and electrical advantages.

The twin-motor drive finally selected for the 54-in. blooming mill consists of two 5,000-hp., 40/80-r. p. m. double-armature motors with a combined maximum torque rating of 3,940,000 lb-ft. Each armature is wound for 350 volts, the two armatures of one motor being connected in series, as shown in Fig. 1. The two motors operate in parallel and receive power from three

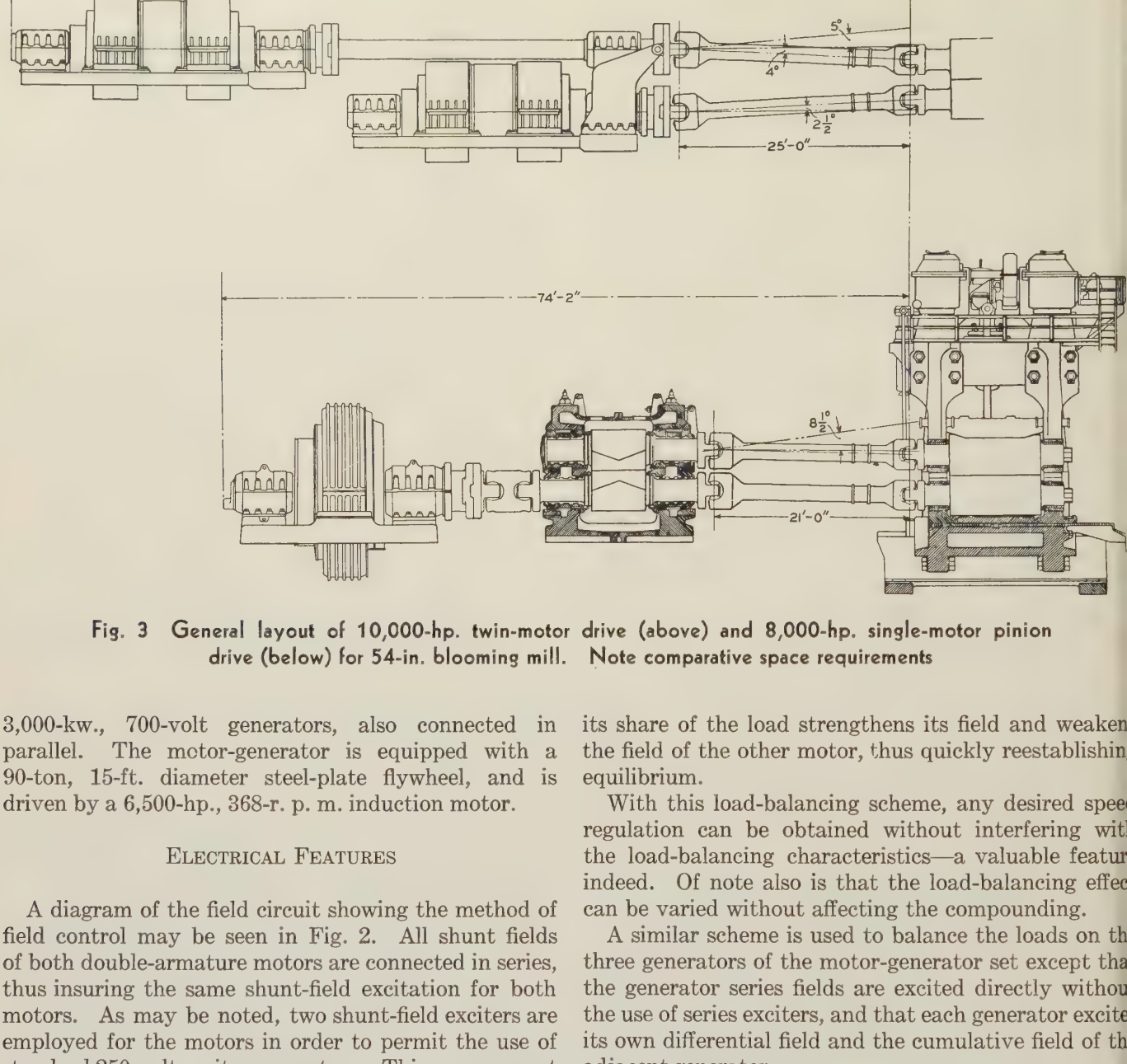


Fig. 3 General layout of 10,000-hp. twin-motor drive (above) and 8,000-hp. single-motor pinion drive (below) for 54-in. blooming mill. Note comparative space requirements

3,000-kw., 700-volt generators, also connected in parallel. The motor-generator is equipped with a 90-ton, 15-ft. diameter steel-plate flywheel, and is driven by a 6,500-hp., 368-r. p. m. induction motor.

Electrical Features

A diagram of the field circuit showing the method of field control may be seen in Fig. 2. All shunt fields of both double-armature motors are connected in series, thus insuring the same shunt-field excitation for both motors. As may be noted, two shunt-field exciters are employed for the motors in order to permit the use of standard 250-volt exciter generators. This arrangement also makes possible the variation of the relative shunt excitation of the two mill motors, if necessary, by means of a buck-and-boost exciter connected across the mid-point of the field circuit and a point midway between the two exciters. Up to the present time, however, no occasion has been found to make use of this latter feature.

In addition to the main shunt-field winding each motor is equipped with a cumulative series field and a differential series field which are cross-connected and indirectly excited by series exciter generators. As shown in Fig. 2 each series exciter generator has its series field in the armature circuit of one double-armature motor, and excites the cumulative field of that motor and the differential field of the other motor. Hence any tendency of one motor to take more than its share of the load strengthens its field and weaken the field of the other motor, thus quickly reestablishin equilibrium.

With this load-balancing scheme, any desired spee regulation can be obtained without interfering wit the load-balancing characteristics—a valuable featur indeed. Of note also is that the load-balancing effec can be varied without affecting the compounding.

A similar scheme is used to balance the loads on th three generators of the motor-generator set except tha the generator series fields are excited directly withou the use of series exciters, and that each generator excite its own differential field and the cumulative field of th adjacent generator.

Mechanical Features

Mechanical arrangement of motor, spindles, an rolls is shown in Fig. 3. The motors are mounted o on 83.5-in. centers. Relative elevations of motors an rolls are such that the lower spindle operates at an angl of 2.5 deg.; the upper spindle runs at an angle of 4 deg below horizontal when the rolls are together and 5 deg above horizontal when the rolls are set for their max mum separation. The mill spindles are 25 ft. lon which is 4 ft. greater than for a duplicate mill wit pinions. The maximum angle of the upper spindle fo the pinion drive, corresponding to the same roll separa tion, is 8.5 deg.

Comparative space requirements and spindle angl

or an 8,000-hp., 40-r. p. m. drive with pinions, and for 10,000-hp., 40-r. p. m. twin-motor drive are shown lso in Fig. 3. As may be noted with the pinion drive, he spindles operate under the most favorable condiions when the rolls are close together. Usually, owever, loads are heaviest when the ingot being rolled s large and the upper spindle considerably inclined. With twin-motor drive the spindle angle is at minimum vhen the rolls are separated considerably; hence with his type of drive the best operating conditions obtain vhen the load is at maximum.

Mechanically, the two motors of a twin drive are dentical. The mill-end pedestal of each motor is upported on a heavily ribbed cast steel baseplate. The sides and front end of the bedplate are fabricated n the usual manner from heavy beams and slabs. The upper motor drives through a jack shaft, an "A" rame on the mill end of the lower motor supporting a edestal bearing which carries the outer end of this haft. Thrust in this jack shaft is taken care of by the nill-end pedestal of the upper motor. The lower motor s provided with the usual type of thrust bearing. Both the motor shafts and the jack shaft have forged langes. Driving halves of the universal couplings ext to the motors are bolted to the shafts in such a way hat they can be removed for renewal or repair. Elecrical construction of the motors is in accord with ccepted practise for reversing service.

Characteristics of Twin- vs. Single-Motor Drives

Operating characteristics of the 10,000-hp. twinnotor drive are quite different from those of a conventional reversing equipment driving through pinions. These differences are indicated in the following comparisons.

1. Quieter operation.

teel enters the rolls without shock. The usual vibration and noise in the ill spindles are absent, and there is practically no tendency for the mill to hatter. Consequently the roller is not required to exert the usual care but an enter the steel on the first trial, even at higher speed thereby saving ime on the early breakdown passes.

2. Greater operating flexibility.

In the pinion drive, independent movement of the rolls is limited by the back-lash in the pinions and spindles; this limitation of movement constitutes the chief cause of roll chattering. With twin-motor drive the phase positions of the rolls can shift independently thereby quickly adjusting themselves to the steel and largely eliminating roll chatter.

3. Higher mill acceleration and retardation.

Comparatively low inertia in the motors allows the control to be designed for unusually fast field response without setting up high reverse power currents. Electrical equipment is therefore used to better advantage and the capacity for useful work is increased.

4. Intervals between passes reduced.

This is brought about by the rapid response of the motors which not only makes the handling of the drive much easier than the usual drive, but also permits the steel to be kept closer to the mill.

5. Total rolling time decreased.

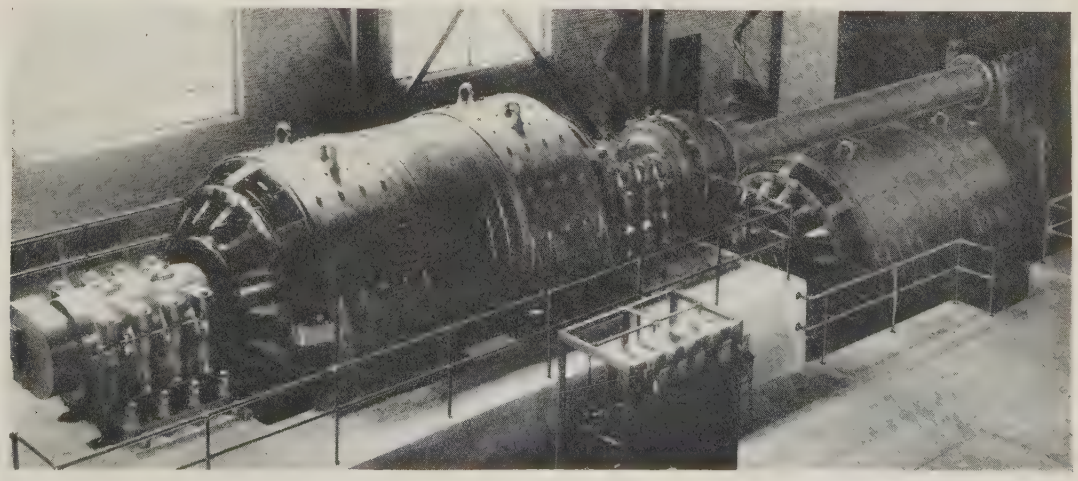
The quick response of the motors increases the entering and average rolling speeds, thereby decreasing the rolling time by increasing the percentage of the time the metal is in the rolls.

Twin-motor drive also has been applied recently to the main horizontal rolls of a 44-in. slabbing mill. This mill is similar to that of the 54-in. blooming mill except that the total capacity of the drive is greater. The main horizontal rolls are driven by a 10,000-hp., 40/80-r. p. m., twin-motor drive similar to that just described. The vertical rolls are driven separately by a 2,500-hp. 79/225-r. p. m. 700-volt reversing motor. The flywheel motor-generator comprises three 3,500-kw. 700-volt generators but otherwise is the same as the blooming-mill set.

Twin Motors for Smaller Mills

The two installations just described are the first applications of twin-motor drive to heavy-duty mills and in addition represent the greatest power which so far has been applied to a single pair of rolls. For mills with 40-in. or smaller rolls requiring motor capacity of 8,000 hp. or less, the drive usually can be simplified by building each motor with a single armature. The smaller motors can be mounted on smaller centers and the spindle angles can be kept within reasonable limits without making the spindles excessively long.

It is possible from both the mechanical and electrical



ig. 4. General arngement of the two ,000-hp. double-rmature motors as actually installed

standpoints to build a reversing mill drive with one motor on each side of the mill. With this arrangement small motor diameter is not an important consideration and the motors can be designed along conventional lines; where both motors are located on the same side of the mill, however, motor design may be somewhat special. However, within reasonable limits, electrical construction details are relatively flexible and each individual installation therefore should be laid out to fit local conditions most advantageously.

Cost and Other Considerations

Relative first costs of twin-motor reversing drive and pinion drive will vary with the size and torque requirements of the mill. The motors of a twin-motor drive with the necessary shafting and bearings are more expensive to build than a single motor of equivalent capacity. This increased cost may be somewhat less than the cost of a pinion stand with spare pinions and bearings for a heavy mill, but somewhat greater than these costs for a light mill. In general, however, the difference in cost is not great and is far outweighed by the many advantages of twin-motor drive.

Twin-motor drive offers advantages also for wide strip mills, whether these are used for hot or cold rolling. The chief advantage in this application is that the elimination of the mill pinions does away with the necessity for accurate matching of the mill rolls. When single-motor drive is used for either hot or cold rolling, unless the rolls are matched accurately, high stresses are set up in the pinions in order that the larger roll will slip and equalize the delivery speeds. With twin-motor drive the motor speeds readily adjust themselves so that each roll has the same surface speed. The problem of load division is quite simple, since wide thin material forms practically a perfect coupling between rolls.

The simplest form of drive for a strip mill is one having a direct-connected motor on either side of the mill, each motor driving one working roll. To this arrangement there may be objections, especially in hot-rolling mills, on account of the space occupied by the motor and spindles on the side of the mill usually left open. This objection can be overcome by the use of special gearing which will permit the installation of both motors on the same side of the mill. And since geared motors with pinion drive are now the usual thing, such an arrangement would introduce no new mechanical complications. The total number of gear units would remain the same, and instead of one reduction unit and one mill pinion unit, each of full capacity, there would be two reduction units, each of half the total capacity.

In recent years the conceptions of steel plant executives and engineers as to the expected output of various sizes and types of mills have become fairly well standardized. Certain standards also have been applied in selecting the electric drives. Where twin-motor drive is to be used, a revision of standards obviously will be necessary. Higher average rolling speed and the reduction of intervals between passes allow the capacity of such a mill to be increased over what would be expected from one with the conventional single-motor drive. The net result is a more advantageous utilization of electrical equipment in the twin-motor drive; hence a greater tonnage output can be realized with no increase in motor capacity. Moreover, in many cases it will be desirable to provide still greater motor capacity than now is customary in order to take advantage of every possibility for increased output.

A Vacuum-Tube Device for Current-Balance Telemeters

The motor-operated rheostat with its associated apparatus now is replaced by a simpler, more compact vacuum-tube arrangement. The only auxiliary power required can be obtained from an ordinary station-lighting circuit; circuit constants are chosen so that momentary dips in this supply voltage do not affect the readings.

By

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AN IMPROVEMENT for current-balance telemetering systems recently has been devised, not only to eliminate the auxiliary motor and special rheostat now commonly used with this apparatus but also to render unnecessary an additional source of d-c. supply. This new improvement utilizes electron tubes for producing and controlling the feeble direct current which constitutes the indicating medium for this type of remote metering.

In general, telemetering systems are capable of a wide variety of applications including not only measurements of electrical quantities but also of many mechani-

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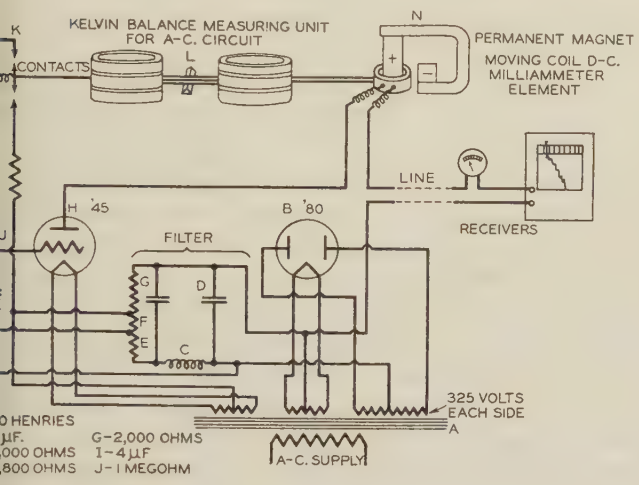
entities; for example, water-level indications in ttended hydroelectric stations. In the *current* e of apparatus as contrasted with other types the iations to be remotely observed are first translated o proportional currents; these are then transmitted r communication lines and measured at the remote eiving point by the usual type of current measuring truments.

The current-balance system constitutes one particular cies of current telemeter, utilizing a mechanism in ich a direct current of *milliampere* magnitude is ulated to be proportional to the quantity being asured; this small direct current then being trans-ted to the remote receiving point. As previously



Schematic diagram of new vacuum-tube transmitter for current-balance telemetering

structed the transmitter in this system consisted entially of a composite a-c.—d-c. balance mechanism which the torque of a-c. measuring coils was balanced inst the counter-torque of d-c. coils. Current in d-c. coils was adjusted by a motor operated rheostat, motor in turn being actuated by contacts on the ance mechanism.

A schematic diagram of the new electron-tube rent-balance transmitter may be seen in the accom-ying illustration. Power, voltage, current, or atever entity is to be remotely indicated is applied the measuring element *L* and produces a torque ding to close one of the contacts *K*. An electro-gnetic counter-torque is established by the d-c. ment *N*, which carries the telemeter current in the mmunication line, this of course being the current asured by the remote receiving meters. These two ques are applied against each other by the composite —d-c. balance mechanism *L-N*. If they do not ance exactly, contacts *K* operate to adjust the ct current (which is supplied from the plate circuit ube *H*) to the balancing value. When the upper tacts close, the grid voltage of tube *H* is increased the plate circuit is correspondingly reduced; when the lower contacts close, the grid voltage is reduced thereby increasing the plate current. The resistance *J* slows down the charging time of the condenser *I* enough to allow the balance *L-N* to open the contacts and stop charging when the proper current value is reached.

Power is obtained for the electron tubes and associated equipment from an auxiliary a-c. supply such as a station lighting circuit. Transformer *A* supplies filament voltages to both tubes, and plate voltage to rectifier tube *B*. This latter tube supplies the d-c. plate and grid voltages for tube *H* through filter circuit *C-D* and resistor *E F G*.

Resistances *E*, *F*, and *G*, are so chosen that *G-F* will produce enough grid voltage to reduce the plate current to zero, when voltage equivalent to the drop on *G* is impressed on the plate. The resistance *F* is so chosen that when a sudden change occurs in the line voltage of the auxiliary supply *A*, no change in the plate current of tube *H* takes place. Thus this resistor arrangement prevents line supply dips from showing on the record, and thereby overcomes a condition existing in previous forms of current-balance systems.

Use of electron tubes in this apparatus eliminates all moving parts used previously, excepting of course those associated with the meter elements. Accordingly the up-keep expense and attention required should be less than with the older type of transmitting system. Life tests made in the laboratory indicate also that under normal operating conditions radio tubes as used in this application should have an average life of much more than a year. In addition to the distinct advantages already mentioned, the apparatus is more compact than the motor-operated device and the currents which contacts *K* are required to handle are greatly reduced being only from 40 to 80 microamperes.

Clinical Sunlight—Natural and Artificial

DISCOVERY of reasons for the well-known beneficial effects of sunlight on health has been a stimulus to efforts to produce artificial sunshine for use when and where natural sunshine is not available. Knowledge of the amounts of energy in various wavelengths of the solar spectrum throughout

From an article written by A. C. Downes, National Carbon Co., for *Research Narratives*, Dec. 15, 1930, published by the Engineering Foundation, Inc., 29 West 39th Street, New York, N. Y.

the year is necessary for production of the best artificial sunlight. Therefore measurements of sunlight in summer, fall, and winter, have been made at two sanatoria, in Ohio and Colorado, where sunlight has been used for years in treating disease. The physicians in charge in Colorado have found that noon winter sunshine has given the best results.

There are indications that several more or less clearly defined bands of the spectrum produce certain biological effects. Most clearly defined is the so-called antirachitic region (limited to wave lengths less than 3,100 Angstrom units), which is included in that portion of sunlight entirely removed by ordinary window glass. (The Angstrom unit is equal to a ten-millionth of a millimeter.) This band is responsible also for sunburn. The band of very short ultra violet (not present in sunlight) below about 2,800 Angstrom units is destructive to bacteria and molds. There are other bands which have specific biological effects but the evidence is not so complete as yet as for the two bands mentioned.

Carbon arcs have been produced closely approximating the amount of sunlight in more or less narrow bands at definite distances from the source, and some of these carbon arcs have been in use for the treatment of disease ever since Finsen began using the carbon arc at Copenhagen about 1895. Finsen's work has been continued by physicians all over the world using various types of carbon arc as well as other sources of light.

The carbon arc has been a useful tool to these investigators as, by the use of various metals and chemical compounds in the carbons, the quality of the light produced can be varied through a wide range. If light rich in the far ultra-violet entirely absent in sunlight as it reaches the earth is desired, the carbons are cored with iron or a combination of several metals such as iron, nickel, and aluminum. Carbons containing silver have been used to produce a strong band in the ultra-violet just above the so-called antirachitic band (2,900 to 3,100 Angstrom units).

Ideal artificial sunshine should have only the wavelengths present in natural light and in exactly the same proportions. At present no artificial illuminant has been produced which exactly duplicates sunlight in the distribution of energy in the various wavelengths, but a light which closely approaches sunlight in quality is given by an arc burning carbons cored or impregnated with salts of the rare earths. There are several chemical elements in these rare earths, but their effect on the light from the carbon arc is due principally to the metal, cerium.

An important property of any carbon arc is that the light emitted is dependent only upon the grade of carbon—that is, the kind and quantity of chemical elements used in the cores—and the current and voltage at which the arc is burned. The quality of the light therefore is independent of the lamp mechanism, but the quantity and direction of the light depend very greatly upon the efficiency of the reflectors and other features of design.

Coordination—
The Essence of Modern Engineering

By
WILLIAM S. LEE President A. I. E. E.

ENGINEERING ENTERPRISE has developed so rapidly from the application of individual technical skill to the combined technical efforts of many and variously qualified persons, that it seems propitious to consider briefly one of the most important of the present controlling features. A modern engineering undertaking of any appreciable size whatever involves influencing factors ranging all the way from the purely political to the purely economic; from the purely theoretical to the most simple and practical. Each of these factors of necessity must contribute its share to the ultimate design or structure, each to be interpreted and applied by a skilled technologist. Thus it is that coordination, hackneyed word though it be, comes to the fore as representing a function without which no engineering enterprise of any magnitude may hope to succeed in the full sense of that word.

Successful operation presupposes coordinated construction which in turn is dependent upon coordinated design, the whole enterprise resting fundamentally upon coordinated man power. The design of a modern complicated project represents the composite thought and combined experience of many minds so carefully blended, so well balanced, and so thoroughly interlocked, that each part will function and work in unison with every other part. Every project of any importance should be carefully designed in its entirety before very much if any of the construction work is undertaken. Only by this means may the construction engineer obtain the necessary insight into the ultimate purpose and use of the undertaking for which he is responsible as well as the strength and character of each integral part, through which insight he may produce the desired results in the finished product. Only with a composite picture of the whole may the construction engineer proceed intelligently and meet modern economic limitations by building safely, quickly, and economically.

The achievement of a perfect structure in this day of broad and rigid requirements would be impossible without the assembled minds and the coordinated efforts of many kinds of engineers and technical specialists. In spite of this well-known fact, however, it is a common

An address delivered at the annual summer convention of the A. I. E. E. Asheville, N. C., June 22, 1931.

acy to look upon the result achieved as being the duct of the efforts of one man. The really big man engineering as well as in other professions is the ple man who readily recognizes and admits the fact t all major enterprises are fundamentally the ducts of well-directed group action. Very often greatest and the most valuable man in a coordina- conference is the man who can abandon his own as to espouse the cause of others in the interest of fied and effective effort.

n pausing for a moment to consider some practical mples we naturally turn to the field of electricity. e of the most perfectly coordinating forces in modern es is found in the transformation of energy into tric power and the application of this new form of rgy into productive work. So perfect is the co- ination that can be secured in the field of electricity t every phase of the almost innumerable detailed rations involved in a modern power plant may be so rlocked by electrical apparatus and so energized by tric power that they operate in perfect unison and ays are ready with instantaneous response to the l of the operator in charge.

To cite another case of mechanical coordination, let consider briefly the modern paper mill with which ny of you are familiar. The real heart of this mill in the long line of rolls. These rolls are steam- ted and over them passes the paper as it evolves m a pulp to the finished product. Due to the fact t absolute uniformity of speed is required it was con- ered impossible until a few years ago to drive these s by any means other than spur gears. The electri- engineer, however, solved the situation by de- ing sensitive and accurate control equipment by ans of which many electric motors may be electrically nterlocked as to maintain rigid synchronism. Thus se many independent motors turn the several rolls wing the endless paper strips through them at a high ed, yet with a smoothness that avoids tearing even most delicate paper.

As another example of coordinated effort consider the ely heralded Empire State Building in New York y. If prior to the completion of that structure you visited the site and inspected the old building n it, and had you been able to view the tremendous ntity of material of almost innumerable kinds that t into it, and then had been told just how long it ld take to remove the old structures and assemble raw materials into a new structure, you could have n pardoned for exhibiting grave doubt as to the sibility of accomplishing such a feat. Yet, as a result trict coordination of design and construction, and coordinated mobilization of the materials which had e brought in piece by piece, that tremendous struc- was completed within a phenomenally short time ts full height of 1,247 ft. above the sidewalk line.

The failure of the designing engineer or the construc- engineer to coordinate their various related nches of engineering, construction, or specializa- tion, can mean nothing but lost energy, lost time, and lost money in any great project.

In engineering, your mission, and mine, is far greater and more important then merely designing or constructing a great project. We must so synchronize the many kinds of engineering and the many kinds of materials involved that the finished product shall be perfect in its design, construction, and operation. In this connection it should be remembered specifically that the ultimate aim in every project is a perfect product rather than a perfect design. In the face of constantly increasing and ever more exacting demands in all kinds of engineering projects, we are training more engineers and more types of engineers year by year as specialists to refine and improve our general designs.

We must go further and maintain that initiative which builds the type of citizenship to which we owe our inventions, our developments, our progress—a citizenship far more valuable than the gold seams of arctic Alaska or the diamond fields of tropical South Africa—a citizenship that recognizes fully the fact that the only true equality in life is equality in opportunity.

In closing I wish to leave a message for the young engineer, and for the engineering student. It is my wish to impress these young men with the fact that opportunities still abound in the field of engineering in general, and electrical engineering in particular. True the specifications are somewhat broader and the requirements materially more rigid than they used to be; but to offset this, the young engineer of today has at his command a wealth of technological information nonexistent in earlier days. In my own opinion the wonderful field of coordination upon which I have touched but briefly now furnishes a new line of endeavor for you young engineers, and opens up a magnificent panorama of opportunity for service to yourselves and to your country.

If it were possible for Opportunity to stand before you today she doubtless would say:

"They do me wrong who say I come no more
When once I knock and fail to find you in;
For every day I stand outside your door,
And bid you wake, and rise to fight and win.

Wail not for precious chances passed away,
Weep not for golden ages on the wane;
Each night I burn the records of the day;
At sunrise every soul is born again.

Laugh like a boy at splendors that have sped;
To vanished joys be blind and deaf and dumb;
My judgments seal the dead past with its dead,
But never bind a moment yet to come.

Though deep in mire wring not your hands and weep;
I lend my arm to all who say 'I can!'
No shamefaced outcast ever sank so deep
But yet might rise again and be a man!

Dost thou behold thy lost youth all aghast?
Dost reel from righteous retribution's blow?
Then turn from blotted archives of the past
And find the future's pages white as snow.

Art thou a mourner? Rouse thee from thy spell!
Art thou a sinner? Sins may be forgiven;
Each morning gives thee wings to flee from hell;
Each night a star to guide thy feet to heaven."

News

Of Institute and Related Activities

Did you ever take a swim a mile up in the air? This is the famous mile-high beach at Lake Tahoe, California

Will You Take "Your Vacation at the Lake Tahoe Convention"?

A TECHNICAL PROGRAM second to none, in which many essentials of present-day demands upon electrical engineering will be set forth and emphasized; a diversive program of which golfing, dancing, feasting, outdoor sports and a multiplicity of other delighting holiday occupations will be the happy ingredients—these are some of the things in store for those who will heed the call and follow the injunction to "Make your vacation include the Tahoe convention;" joys which shortly will be linked irrevocably with recollections of the Institute's twentieth Pacific Coast convention to be held August 25-28, 1931, now bearing high promise of being "the best one ever." And who will not enjoy the climax of Wednesday evening August 26, with a real barbecue followed by a general meeting and subsequent entertainment?

Technical Program

With L. F. Leurey (M'27) of San Francisco in the chair, the technical sessions will open with the presentation of three papers devoted to the profession in industrial application. The second session presided over by S. J. Lisberger (M'11) chief engineer in charge of the division of electric distribution and steam engineering, Pacific Gas & Electric Company, will offer an interesting and instructive collation of facts on a-c. networks, the Mokelumne River development (by Mr. Lisberger's own company), line control of interconnected networks, and "tuned" power lines. Wednesday, August 26, with C. E. Fleager (F'26 and vice-president) chairman, will be given over to a new and detailed study of the ever active subject, communication; on this occasion from both community and intercontinental standpoints. In the evening, convention guests will be afforded the pleasure of listening to C. E. Grunsky, internationally known president of the American Engineering Council, who will address the convention concerning "business and economics," a subject never more vital than at the present moment.

The technical program will come to a

tting close with Friday morning's session n electrophysics and general subjects ncluding cathode drops in arcs and glow ischarges, the kindling of electric spark-ver, snow surveys, and radio coordina-on; R. W. Sorensen (F'19) professor of lectrical engineering, California Institute f Technology, presiding.

Entertainment

As earlier paragraphs suggest, an ample rogram of entertainment has been earched out and perfected by diligent ocal committees. In addition to diver-ions already named, there will be held on 'riday evening "A Night at Monterey," gala celebration modeled after the panish fiestas of old. Tahoe Tavern and ake Tahoe on the shore of which it is ocated are unexcelled for pleasures and eauty of surroundings. Tennis, swim-ning, golf, horseback riding, and an xceptionally fine bowling alley all are vailable within the Tavern grounds, while the Kit Carson Trail to the historic ining cities of Carson and Virginia City n Nevada offers a short, but ultra scenic rip. The usual tournament for the 'isken Cup, Pacific Coast A. I. E. E. golf rophy, will be played on the Tahoe ourse. The majority of interesting oints may be visited with ease and omfort in less than a day's time for the ound trip.

The ladies have been specially planned or of course; a boat ride to Emerald Bay, ridge parties, and automobile trips have een carefully arranged for all those nterested in their participation. On the vening of Thursday, August 27, a short laylet will be staged "to provide fun for ll"?

The "Night in Monterey" will be held or the most part upon the delightful and ell-equipped beach and boardwalk, bly engineered by the management of he Tavern.

Vacation Suggestions

In line with the promise of the con-ention's part in vacation plans it should e remembered that Lake Tahoe is in the ery heart of California's famous Sierra Nevada mountain range. In almost every irection trips upon the lake offer an ntry into splendid mountain scenery. osemite Valley, the historic Mother ode gold mining country, Sequoia and eneral Grant National Parks, and other ttractive spots are daily reached by good oads from the main highways in central nd southern California. Members coming om or through Oregon and Washington ill find Crater Lake, the Oregon Caves, nd the Coast highway through the mous redwood belt delightful and ecreative.

Attractive convention rates will be ade available to members and guests at Tahoe Tavern for the entire week of August 23 to accommodate those wishing to devote a few uninterrupted days to pure diversion.

Registration and Hotel Accommodations

A general information and registration desk will open in the lobby of the Tavern Monday, August 24, and delegates and guests are requested to call there as soon after arrival as possible to obtain badges and news of convention schedule. The following fees covering registration, banquet, all scheduled events, and greens fees for the golf tournament will be in effect:

Members and men guests	$5.00
Ladies	3.00
Student members	1.00
Student guests	2.00

Tickets for the Thursday evening banquet are for only those registering for the convention; this applies to members, men and women guests, enrolled students and student guests. Tahoe Tavern is offering special convention rooming rates to Institute members and their families attending the convention. Many of the exceptionally large rooms are suitable for groups of four or five, and better to accommodate the unusual number of persons expected the management hopes that those who care to take advantage of this club arrangement will make up their own parties and thus simplify the question of hotel space allotment. Convention rates including meals will be as follows:

Room or small suite with bath (shared by 1, 2, or 3) per person per day	$8.00
Room or suites with bath (shared by 4 or more) per day per person	7.50
Room without bath, per person per day	7.00

All reservations must be made through the hotel committee by means of the regular hotel reservation blank provided; registrations made direct with the Tavern will not be recognized to benefit by convention rates. Order of receipt will establish precedence of choice of accommodations, etc.

The Fisken Trophy

The John B. Fisken Cup, much coveted golf trophy, is awarded annually to the best tournament score among members of the Pacific Coast Sections from 18-hole medal play at handicap. Many other prizes also will be awarded, all of which should make the tournament a feature attraction to any enthusiastic registered delegate or guest. No greens fees will be charged for the tournament, but specific information establishing handicap, etc., should be returned with the registration card.

Transportation

Excursion rates are available from all points, railroad service to Lake Tahoe being provided by the Southern Pacific Company via its Overland Route. Spe-

Tahoe Tavern, headquarters of the forthcoming Pacific Coast convention

The annual tournament for the John Fisken cup will be played among the pines of the majestic "High Sierra"

cial routing information for making the trip by auto travel through most historic and scenic territory is made available by The Pacific Gas & Electric Company which will arrange to have its local representatives along all routes to the Lake to furnish specific information and render any possible service in case of emergency.

Committees

General convention committees and officers serving in the various departmental divisions of convention activities are as follows:

Chairman, A. W. Copley (F'26); vice-chairman, P. B. Garrett (M'30); both of Westinghouse Electric & Mfg. Company, 1 Montgomery Street, San Francisco, Calif.; secretary, E. F. Maryatt (M'27) of the Pacific Gas & Electric Company, 245 Market Street, San Francisco, Calif. Committee chairmen include A. G. Jones (A'07) *entertainment*; E. A. Crellin (F'28) *finances and hotel*; A. V. Thompson (A'23) *golf;* F. R. George (M'25) *inspection trips;* W. C. Heston (M'20) *publicity;* M. S. Barnes (A'18) *registration;* C. E. Fleager (F'26 and vice-president) *reception;* D. I. Cone (M'24) *technical program;* S. G. Palmer (A'15) *student activities;* P. Lebenbaum (M'13) *transportation;* and Mrs. Hector Keesling, *ladies' entertainment;* assisted by C. E. Carey (M'25), H. B. Carpenter (F'18 and vice-president), J. N. Chamberlain, L. B. Fuller (A'03), L. F. Fuller (F'23), A. V. Guillou (M'27), J. Hellenthal (M'23), H. W. Hitchcock (M'27), G. L. Hoard (A'19), A. H. Kruel, P. J. Ost (M'23), W. C. Smith (M'26), and L. A. Traub (A'28), members of the local committee.

Technical Program

Tuesday, August 25

10:00 a. m. Industrial Applications—L. F. Leurey, chairman.

Electrical Power in Wood Products Industry, by C. E. Carey and K. L. Howe, Westinghouse Electric & Mfg. Company, Seattle, Wash.

Application of Electricity to Oil Field Operation, by H. C. Hill and J. B. Selegue, Los Angeles

Correlation of Induction Motor Design Factors, by V. Hoover, Teaching Fellow in E. E., California Inst. of Tech.

2:00 p. m. Power Transmission and Distribution—S. J. Lisberger, chairman

Economics of A-C. Networks for Secondary Distribution, by S. B. Clark, Portland, Ore.

The Mokelumne River Development of the Pacific Gas & Electric Company, by E. A. Crellin, E. M. Wright, and B. D. Dexter, Pacific Gas & Elec. Company, San Francisco, Calif.

Tie-Line Control of Interconnected Networks, by C. A. Powel, Westinghouse Elec. & Mfg. Company, and T. E. Purcell, Duquesne Lt. & Power Company, Pittsburgh, Pa.

Tuned Power Lines, by H. H. Skilling, Stanford University

Wednesday, August 26

9:30 a. m. Student Technical Session No. 1

2:00 p. m. Communication—C. E. Fleager, chairman

Intercontinental Telephone Service, by J. J. Pilliod, engineer, American Tel. & Tel. Company, New York, N. Y.

Electrical Solutions of Problems of Regular Scheduled Flight, by C. F. Green, Schenectady, N. Y.

The San Francisco–Los Angeles Section of the Pacific Coast Telephone Cable Network, by E. M. Calderwood, San Francisco, and D. F. Smith, Los Angeles, both of the Pacific Tel. & Tel. Company

Electrical Sound-Absorption Measurements, by A. L. Albert and W. R. Bullis, Corvallis, Ore.

Evening

Barbecue dinner

Address by C. E. Grunsky, president of American Engineering Council "Business Cycles and Some Economic Problems"

General meeting followed by entertainment

Thursday, August 27

8:00 a. m. Student Breakfast and Conference

Afternoon

Sports

Evening

Banquet and playlet

Friday, August 28

9:30 a. m. Electrophysics and General Subjects—R. W. Sorensen, chairman

Cathode Drop in Arcs and Glow Discharges, by S. S. Mackeown, California Institute of Technology, Pasadena, Calif.

The Kindling of Electric Sparkover, by C. E. Magnusson director of engineering experiment station, University of Washington, Seattle

Snow Surveys, by H. P. Boardman, professor of C. E., director of engineering experiment station, University of Nevada, Reno

Radio Coordination, by H. N. Kalb, Great Western Power Company, and C. C. Campbell, Pacific Gas & Electric Company, San Francisco

Irrigation Waste to Run Texas Plant

A hydroelectric plant to be built by the Central Power & Light Company near Eagle Pass, Texas, will utilize waters returned from the Maverick County Irrigation District No. 1, after they have been diverted for irrigation purposes and carried back by a supply canal to penstocks.

Excavations for the power house of this plant were started May 23, 1931; it is expected that the plant will be ready for operation early in 1932. The generators will be of 3,500 kw. 6.9 kv. umbrella type, the power produced to be transformed to the higher voltages in an adjacent substation. A 66-kv. line coming from the East supplies power for construction now and will be used later to carry power to the operating company's other points of distribution. During the irrigation season the river flow amounts to approximately 1,000 sec-ft. but at certain other seasons it reaches a 1,500 sec-ft. volume—*Wendell C. Fowler, San Antonio Section Correspondent.*

Asheville Convention Closes Busy Institute Year

WITH more than 500 persons in tendance the Asheville convention oved a fitting climax to a busy year. ssentially every District and active ction throughout the United States d Canada and including Mexico City, ere represented It was of particular terest to note the high percentage of omen guests who attended from distant oints giving color and lending charm to affair already under the spell of spitality so typical of the Old South.

Importance of District Meetings Stressed

In a prelude to his final formal address efore the Institute President Lee nphasized again his fervent wish to Take the Institute to the members in- ead of trying to bring the members to e Institute." In this connection he nphasized the increasing value of istrict meetings, urged every effort to velop them, and outlined current ogress in that direction. President Lee so called attention to the great value of e younger members to the Institute and the Institute to the young electrical gineer, urging a greater participation the part of the younger men. In his rmal address, full text of which appears ewhere in this issue, he sounded a allenge and a distinct note of encourage- ent to engineering students.

elegates Sessions Well Attended

Two particularly well attended ses- ons of delegates, officers, and members ere held at which several subjects of rticular import to Institute members ere rather fully discussed. These cluded the licensing of engineers, mem- rship problems including transfer quali- ations, and Section and student Branch erating problems. More concerning of these subjects will be presented in LECTRICAL ENGINEERING as the various mmittee studies and reports are com- eted. Technical sessions all were very ll attended, attendance being en- nced perhaps by the fact that many of e sessions were held on the open randas of the Grove Park Inn overlook- g the North Carolina mountain scenery. brief outline of the several papers esented is given in the paragraphs that low; discussion will be reviewed in a bsequent issue.

Interconnections Discussed and Evaluated

RECOGNITION of some of the technical problems involved in the present-day trend toward mergers and large cooperative undertakings in the field of the electric service company, an entire session of the Asheville summer convention was devoted to a symposium of four papers on this general subject.

In his paper relating to the classification and evaluation of interconnection services A. E. Bauhan (M'17) of the Public Service Electric & Gas Company, Newark, N. J., defined his interpretation of the word *interconnection* as meaning the physical tying together of two or more independently owned or separately managed electric systems for the purpose of realizing financial benefit or service improvement through the interchange of power.

Under the heading of service classification the author listed emergency service, load diversity, firm power, storage power, intra-company use, economy flow, and unintentional flow. He expressed the hope that these seven suggested classifications would form the basis of discussion and experiment which would lead eventually to a generally acceptable classification and nomenclature.

Economic Evaluation

After defining and describing these classifications in some detail, Mr. Bauhan launched into a discussion of interconnection service evaluation, stating that such evaluation represented the economic basis upon which the desirability of a proposed interconnection should be made. He stated that the services previously mentioned may be evaluated as to capital cost by determining the aggregate saving in the cost of generating capacity, and then comparing the result with the capital cost of the interconnection itself.

Stating that "interconnection is only one of the many factors contributing to the accomplishment of the purpose of the electric utility industry," G. M. Keenan (F'29) superintendent of the Penn-New Jersey Interconnection (Hazleton, Pa.) pointed out that the "possibilities of interconnection can be realized only when the system is effectively developed and operated."

Diverse Interests of Participants Must be Coordinated

Mr. Keenan emphasized the limiting feature represented by the fact that while interconnected systems operate as a unit, the companies owning them have diverse interests which must be sufficiently coordinated to make available to all participants the maximum benefits to be realized by interconnection. Mr. Keenan stated also that interconnection development usually tends to reduce generating costs at the expense of increased transmission costs and hazards, concluding that "possibly there are some limits to the size of the interconnected system and the degree of coordination desirable between ownership."

The interconnected system representing ten independent operating companies of western Pennsylvania, eastern Ohio, West Virginia, and Maryland, were described at some length by H. S. Fitch (A'18) of the West Penn Power Company, Pittsburgh, whose paper reflected the operating practise and experiences of that group. He described the territory served by these companies and outlined the benefits derived by the interconnection as including a reduction in spare capacity, investment and operating economies effected through (1) dovetailing of construction programs; (2) joint financing of power stations and transmission lines; and (3) noteworthy protection of service continuity.

Disadvantages More Than Offset by Benefits Derived

E. W. Dillard (M'30) and W. R. Bell (A'15) of the New England Power Engineering & Service Corporation, Boston, Mass., described in some detail the various practical problems involved in a typical New England interconnection involving systems in parts of six states. After outlining the history and development of the various interconnections, the authors gave as the objectives of their system the following:

1. The absorption of surplus hydro power from systems generating largely from unregulated hydro sources.
2. The absorption of large quantities of surplus steam with resultant good load factor on relatively high-grade steam plants of adjacent systems.
3. Arrangements for the purchase of surplus steam capacity in various stations which resulted in a certain amount of firm capacity.
4. The sale or purchase of firm power.

The authors outlined in some detail the benefits derived from these various factors, described the contractural relations entered into in the various cases, and pointed out certain disadvantages and difficulties encountered. They stated definitely, however, that they "do not believe that any disadvantages have come about in any New England interconnection that are not offset entirely by benefits derived."

Transients Important in Electrical Machine Design

ELECTRICAL machinery and its design and operating characteristics, always of interest in Institute conventions, were no exception at Asheville. This time the subject of electrical transients seemed to dominate in all presentations and discussions.

The problem of reestablishing excitation of a loaded alternator operating in parallel with others was discussed at some length by D. D. Higgins (M'27) and E. Wild (A'27), both of the Commonwealth Edison Company, Chicago. The authors described tests performed with large turbine-generators operating under load, and gave a résumé of various answers to a questionnaire bearing upon the phenomena accompanying the interruption and reestablishment of a generator's d-c. excitation. As a result of their investigation the authors conclude that the reexcitation of a generator without removing it from the bus is a justifiable and safe operating procedure and one which will restore all conditions to normal in the shortest time.

Reactance and Time Constants Calculated

L. A. Kilgore (A'29) of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., presented a highly mathematical dissertation pertaining to a method of calculating reactance constants and time constants, as they affect transient characteristics of synchronous machines. The author pointed out that recent theoretical advances have introduced many new constants; also that most of the discussions on such constants published previously have been concerned with the *application* rather than the *calculation* of the values involved. In his paper Mr. Kilgore calculated the more significant constants and gave comparisons between tests and calculated values to support the accuracy of his method. In two extended appendices he gave formulas for salient-pole machines and turbine-generators, and pointed out that because of differences in construction many of the formulas for turbine-generators are different from those for salient-pole machines. He discussed the more important differences.

As a companion paper to Mr. Kilgore's, S. H. Wright (A'29) also of the Westinghouse Company presented an extensive treatise descriptive of the determination by test of synchronous machine reactances, resistances and time constants. The author emphasized the practical side of the situation basing his statements and conclusions upon observations made from many tests and their results. Mr. Wright considered three classes of synchronous machines—turbine-generators, salient-pole machines with dampers, and salient-pole machines without dampers. In his tests the author achieved saturation effect under short circuits by applying short circuits to machines operating at rated voltage. He discussed in some detail the more important of the variable saturation effects, and by defining certain saturation and other values attempted to provide a definite basis for the practical specification of machine constants.

Transformer Transients Affected by Many Factors

An essentially mathematical study of transient voltages in transformers and similar equipment was presented by L. V. Bewley (A'27) of the General Electric Company, Pittsfield, Mass. Mr. Bewley devoted his major effort to showing the effects on voltage distributions of wave shape, circuit constants, and neutral impedances, and in describing methods by which the voltage distributions may be controlled or varied. He derived a general differential equation for a circuit consisting of distributed self- and mutual-inductance, series and shunt capacitance, series resistance and conductance along the stack to ground. The author presented (1) numerous solutions of his equation covering various sets of conditions; (2) equations corresponding to many different applied waves showing the effects of wavelengths, wave front, etc.; (3) equations for calculation of potential difference or voltage gradient between points in windings; and (4) tables showing the influence of various circuit constants on wave characteristics.

In describing field transients in magnetic systems, Ernst Weber (A'31) of the Brooklyn (N. Y.) Polytechnic Institute gave a comprehensive mathematical solution of the situation arising from the sudden application of a d-c. voltage through an electromagnetic circuit containing a partly laminated and partly solid iron core with an air gap. Ranging in mathematical manipulations from Maxwell's field equations for eddy currents and magnetic field in an iron core to Heaviside's operational calculus, the author achieved results which he expressed by means of a time constant of the magnetic field. In discussing the practical application of his results the author gave a numerical example and called attention to the effectiveness of quick response excitation for improving electric system stability under short circuit conditions, particularly where large synchronous generators are involved.

Efficient Communication Facilities Required for Successful Operation

REFLECTING the important position occupied by communication facilities in the successful operation of a modern electric light and power system, a symposium of five papers dealing with important phases of the subject occupied one entire technical session of the Asheville convention. Nine different authors collaborated in the preparation of these papers representing some five different power systems and three different divisions of the Bell Telephone System.

In practically all cases the three major divisions of communication service that received specific attention were those pertaining to (1) operating activities including dispatching, plant and substation operation, line patrol and repairs; (2) customer service activities including new installations, disconnections, transfers and service complaints; and (3) administrative activities including executive, sales, and business functions as differentiated from the service functions.

Principal Requirements Outlined

Fundamental considerations underlying the planning and providing of adequate and economical communication services for electric utilities were rather fully outlined and briefly discussed in a paper prepared by R. N. Conwell (F'31) of the Public Service Electric & Gas Company, Newark, N. J., G. M. Keenan (F'31) superintendent of the Penn-New Jersey Interconnection, Hazleton, Pa., C. F. Craig (M'27), special representative of the American Telephone & Telegraph Company, New York, and E. C. Briggs of the Ohio Bell Telephone Company, Cleveland. These authors described the normal workings of an electric utility as

eing so divided that all three clases of ommunication service mentioned in the receding paragraphs are required. In nlarging upon the subject of communica-ion facilities for operating activities, they tated that such facilities needed to be:

1. Easy to operate and capable of establish-ng prompt communication connection.

2. Available at times when generating and istribution facilities are in trouble.

3. Of sufficiently good quality to avoid isunderstandings and to permit conversations o be carried on with ease.

4. Adequately protected from the safety tandpoint but not to a degree that would inter-ere with communication service during electric ervice difficulties.

5. Of sufficient capacity to obviate serious elay even under emergency conditions.

EASED LINES PREFERRED TO CARRIER SYSTEMS

E. S. Bundy (M'30) of the Buffalo N. Y.) Niagara & Eastern Power Cor-oration, described the communication acilities of the western division of the Niagara-Hudson system. He character-zed the modern tendency of interconnect-ng electric generating and transmission ystems as leading to systems covering such large areas that the communica-ion lines have become almost as impor-ant as the power lines themselves."

Mr. Bundy described the communica-ion requirements of his system which nclude remote metering, system dis-atching, load supervision, commercial usiness, and ordinary interdepartmental ommunication. Perhaps the most im-ortant communication service in that ystem is provided by lines leased from he telephone company, arranged in some ases so that conferences involving several ersons may be held over the lines. ingle-frequency duplex carrier-current nstallations providing two-way com-nunication between eight of the more nportant stations on the consolidated ystem supplement the line service. Under normal operating conditions leased nes are used in preference to the carrier ystem because of the better quality of ransmission.

A description of the communication eeds of a power company serving a large etropolitan area was given by P. B. uhnke (M'20) of the Commonwealth dison Company, Chicago. Detailed nformation pertaining to load dispatch-ng problems on his system were dis-ussed, and the use of remote metering cilities as an effective aid in conducting ad dispatching operations was de-cribed. On this system the technical roup in the load dispatching office is in rect private wire communication with l generating and distribution stations, nd with most substations. In describ-g his remote metering system Mr. uhnke mentioned that metallic telephone circuits now are used exclusively but stated that since telemetering impulses now can be transmitted over carrier-current communication systems, the use-fulness of such carrier systems has been enhanced materially.

COORDINATED SYSTEMS MOST ECONOMICAL

C. A. Booker of the New England Power Association, Boston, and M. E. Clark of the New England Telephone & Telegraph Company, Boston, described at some length a cooperative study of power system communication conducted jointly in New England by the power company and the telephone company. The prob-lems there encountered involved a survey of existing communication facilities in the several districts effected, the determina-tion of present and future communica-tion requirements, and the analysis of these requirements to ascertain what improvements, changes, or additions should be made. Coordination of exist-ing facilities both on the Bell system and on the Power Association's various pri-vate lines was the watchword of the joint investigation.

Switching from the communication problem of the relatively closely knit interconnected system to that of the relatively far flung interconnected system, E. C. Stewart of the Arkansas Power & Light Company, Pine Bluff, Ark., de-scribed the communication system in use on the Arkansas - Louisiana - Mississippi Interconnected Power System. Long dis-tances between stations are the regular order of affairs on that system, and as a result carrier-current telephone equip-ment is used to a large extent, the longest distance so served being 459 mi.

After outlining the history of devel-opment and describing the problems incident to the development of the carrier-

"The Engineer Views Hopefully the Hitherto Unattainable"

SUCH is the message of the Lamme Medal established by a bequest of Benjamin Garver Lamme, chief engineer of Westinghouse Electric & Manufacturing Company, who passed away July 8, 1924, after a life of professional usefulness. According to provisions of the bequest, a gold medal accompanied by a replica in bronze goes in award each year to a member of the Institute "who has shown meritorious achievement in the development of electrical apparatus or machinery." William J. Foster, D. Sc., consulting engineer (retired) of the General Electric Company, Schenectady, N. Y. was this year's recipient (see p. 230, ELECTRICAL ENGINEERING, March 1931). A similar bequest was made by Mr. Lamme to Ohio State University, by which annual award is made to a graduate from any of its engineering branches "for meritorious achievement in engineering or the technical arts;" while a third medal is awarded by the Society for the Promotion of Engineering Education "for accomplishment in technical teaching or actual advancement of the art of technical training." The first Lamme Medal to be awarded by the Institute (1928) was given to Allen B. Field (F'13) consulting engineer, Manchester, England; the second to Rudolph E. Hellmund (F'13) chief electrical engineer, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. C. E. Skinner, assistant director of Engineering, Westinghouse, received this year's award from Ohio State. (See p. 519 of this issue.)

current system, the author related some operating experiences. He said "the carrier-current installation on the interconnected system, supplemented by the use of toll service, and one or two leased or specially arranged circuits, is primarily for use by the dispatcher, but considerable business traffic is handled by the dispatching force outside of any rush period."

Automatic Control is Proving its Merit

CONCERNED with the general subject of automatic equipment five papers were presented at an Asheville session. Two of these dealt with the details of supervisory systems for electric power apparatus, one dealt with automatic combustion control, and two presented rather comprehensive outlines of actual operating experience with automatic and supervisory control equipment.

R. M. Stanley (F'23) of the Byllesby Engineering & Management Corporation, Chicago, Ill., described briefly the miniature switchboard supervisory automatic control equipment installed at the Ohio Falls Hydroelectric Station at Louisville, Ky., and gave a résumé of three years' operating experience with that equipment. Mr. Stanley gave the engineering reasons for the adoption of miniature supervisory switchboard and automatic control as being a desired reduction in capital expenditure, and reduced fixed and operating charges. As a result of his experiences he has concluded that automatic devices greatly enhance the services of a capable operator, and produce better station operation than would be possible by a manual system of control alone.

Inspection and Maintenance Important Items

In a jointly prepared paper Garland Stamper (A'25) of the Columbia Engineering & Management Corporation, Cincinnati, Ohio, and F. F. Ambuhl (M'26) of the Toronto Hydro-Electric System, Toronto, Ont., Canada, described their respective operating experiences with automatic station and supervisory equipment. Mr. Stamper stated that the Columbia system has had automatic and semi-automatic stations of various types in operation for the past ten years, and as a result of experience stated emphatically that the degree of satisfaction secured in the operation of any type of automatic equipment is directly dependent upon the quality of inspection and maintenance.

Mr. Ambuhl reported that on the Toronto system automatic controls have given fairly satisfactory results and the supervisory controls have given excellent results, especially the cable-type supervisory." Relay failures constitute the chief source of trouble mentioned.

An a-c. supervisory control system devised to accomplish all that the more common d-c. supervisory systems now do, was described by O. K. Marti (M'27) of the American Brown Boveri Company, Inc., Camden, N. J. The equipment was said to be independent of interruptions in the a-c. supply at stations where it was installed, since it depends upon a small motor-generator set driven from the station battery. For this system five wires between stations are required, two being common supply lines, one a synchronizing wire, one a control wire, and one an indication wire.

Centralized Control Important in Railway Electrification

The Pennsylvania Railroad in its electrification in and around Philadelphia has made use of two installations of supervisory control for the remote operation of high-voltage a-c. step-down substations supplying energy to its traction system. The equipment used and the system involved were described by C. P. West (M'28) of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, and H. C. Griffith of the Pennsylvania Railroad Company, Philadelphia, who stated that the normal practise of the railroad has been to install substation control in signal towers adjacent to substation location, because most substations have been near 24-hr. signal towers. Conditions are changing, however, and the system is expanding beyond the normal operating radius of signal towers. The authors state that from the many advantages of centralized control, this method is destined to play an increasingly important part in future railroad electrification.

Automatic Systems for Accurate Combustion Control

Since heat-power plants have increased so enormously in size, and combustion practise reduced so nearly to an exact science, automatic combustion control has become an economic necessity according to C. H. Sanderson (F'18) and E. B. Ricketts of the New York Edison Company, who presented a joint paper describing several of the more important automatic combustion control systems. The authors cited as being among the important advantages: (1) the uniform loading of all boiler units; (2) instant response to changes in load; (3) correct proportion of fuel and air supply at all times; and (4) a ready means of providing for safety in operation through sequence interlocking of auxiliary equipment.

High-Voltage Cable Practise Continues to Advance

IN an Asheville session devoted exclusively to the subject of cables, the discussions presented ranged all the way from the most highly theoretical to the most practical. Three research workers, four manufacturers, and one prominent operating man presented papers representing their various fields of interest and thus contributed to a better general understanding of the subject.

Results of still further study on the open question hinging on the influence of residual air upon cable insulation life, were presented in a paper by J. B. Whitehead (F'12) and F. Hamburger, Jr. (A'26) of Johns Hopkins University, Baltimore, Md.,—their third A. I. E. E. paper on that subject. As a result of their intensive investigation, the authors have concluded among other things that:

1. The life of impregnated paper insulation increases steadily with a decrease in the amount of residual air.

2. For impregnating pressures above 2.5 cm. the life decreases rapidly with increasing pressure of impregnation. For pressures below 2.5 cm. the results show an increase of life of from 10 to 50 per cent between 2.5 cm. and 2 mm. impregnating pressure.

3. For impregnating pressures below 2.5 cm., normal variations in material and structure, particularly in the tightness of the structure, may offset the increased life due to decreasing the pressure of impregnation.

4. Cable compound deteriorates if it contains only a small amount of air even though kept in sealed containers, at room temperature. To avoid deterioration air should be entirely excluded.

5. Flat power-factor voltage curves and the absolute value of power factor should not be accepted as indications of long life.

6. Power-factor rise due to the initial application of voltage during a life test is indicated as a possible criterion of insulation life.

7. A very satisfactory type of sample and a reenforced end for accelerated life tests have been developed.

8. Narrow variations in the quality of both paper and oil may cause wide differences in the electrical characteristics and in the lives of the impregnated products.

Insulation Variability Limits Allowable Operating Stresses

M. C. Holmes (A'26) of West Virginia niversity, Morgantown, presented a aper describing a method of analyzing e effect of insulation variability in e determination of breakdown voltges and allowable operating stresses. e emphasized the necessity of considerg the variability as well as the so-called rength of insulation and quoted terms allowable operating stresses and failures support of his contentions. He deloped and discussed the application of a neral equation, giving in terms of two arameters the breakdown voltage and e number of failures to be expected, the ean breakdown voltage, and the varibility of insulation.

Oil-filled cables and accessories were scribed by R. W. Atkinson (F'28) and . M. Simmons (F'28) of the General able Corp., New York, N. Y., who efined the term "oil-filled" as being rdinarily understood to indicate a cable which the compound is of such viscosity to be fluid at all operating temperares.

General theory and some of the outanding characteristics of oil-filled cable ractise were discussed in some detail by . B. Shanklin (M'29) and F. H. Buller M'29) of the General Electric Company, chenectady, N. Y.

Better Cables at Lower Costs Predicted

An illuminating and fairly compreensive outline of economic high-voltage ble practise based upon extensive search and intensive practical applicaon was given by D. W. Roper (F'14) the Commonwealth Edison Company, hicago. In illustrating the salient points his discussion Mr. Roper presented merous data and diagrams. He called on utility companies to improve their andards of design and workmanship to ep pace with cable improvements fected by manufacturers. He stated finitely that in his opinion the present te of improvement in the art of highltage cable practise would continue in cceeding years, and further in predicon said that:

1. Cables of all types and voltages will be erated at maximum temperature of from 85 90 deg. cent. without fear of deterioration.

2. Extensive oil reservoirs and accessories on -filled cable will be eliminated.

3. An installation of oil-filled cable will be no re complicated than a present day installation ordinary cable.

4. Cable of subnormal quality will be elimited by factory tests.

5. Initial costs per kva. of 66-kv. cable mpletely installed will range from 30 to 40 per cent lower than the present cost of ordinary cable.

6. Cable failures due to all causes will not exceed one per 100 mi. per year.

Standardization of Units an International Problem

ELECTRICAL units, their modernization, international standardization, precise determination, and proper application is a subject occupying a great deal of the time of many learned technologists throughout the world. Advancement in the art and science of electrical engineering has given rise to a rather concerted study of electrical units along the lines as just indicated, to say nothing of international effort to arrive at a logical and representative nomenclature. Reflecting the importance and timeliness of the subject, the fourth session of the Asheville convention was devoted to a symposium of four papers on various phases of the subject.

H. B. Brooks (F'31) of the Bureau of Standards, Washington, D. C., treated at some length the unit of electrical resistance, going into its past history, and outlining impending changes. The author described the mercury ohm as having been so long legalized as a material standard of resistance that it is regarded widely as a permanent institution of relatively precise proportions, but stated that practically it is obsolescent because of the technical difficulties attending its use. The author further characterized the mercury ohm as a necessary but expensive evil holding its place because formerly it could be reproduced more precisely than could the agreement between the results of absolute determinations of the ohm. He concluded his presentation saying that the technique of absolute determination has improved until now it may be said to be at least on a par with the mercury ohm as to reproducibility. Consequently this method should be used to obviate the laborious and time-consuming effort of high grade men now going into repetitions of mercury ohm determinations.

Standards Must Keep Pace with Advances in Equipment

In a discussion of electrical units and their application, L. T. Robinson (F'12) of the General Electric Company, Schenectady, N. Y., emphasized the necessity of providing for the advancement of precise definitions and precision standards to keep pace with contemporary advances in equipment. In speaking of the importance of accurate measurements as far as scientific advance is concerned, he said "progress and improvement are made possible only to the extent that those interested in and working along the line of developing and improving measuring methods and instruments are able to anticipate the needs of those interested in the development and operation of systems, devices, and apparatus."

Pertaining to the international standard of electromotive force, and its low-temperature coefficient form, Marion Eppley (M'31) of the Eppley Research Laboratory, Newport, R. I., described at some length the great difficulty in achieving the physical conditions prescribed in the officially agreed upon fundamental definitions of certain electrical units. He described briefly several different types of so-called standard cells for reproducing physically a standard volt, discussing also various tests made on and the characteristics of the cells. He concluded definitely that his fifteen years of work on the cadmium cell have given him "ever increasing confidence in its reliability," even if it "is by no means foolproof."

Laboratory Potentiometers Discussed in Detail

Information pertaining to the design of d-c. laboratory type of potentiometers was given by I. M. Stein (M'27) of the Leeds & Northrup Company, Philadelphia. The author treated his subject under the following ten headings: (1) early history; (2) factors affecting voltage range; (3) factors affecting potentiometer resistance; (4) low-voltage potentiometers; (5) analysis of potentiometer errors; (6) self-checking features of potentiometers; (7) galvanometer considerations; (8) comments on volt-boxes; (9) deflection potentiometers; (10) the potentiometer in industry.

Research Problems Vie with Cooperative Education

COOPERATIVE educational methods competed with transmission stability research problems for the attention of those attending the closing session of the summer convention.

D. C. Jackson, Jr. (F'30) of the University of Kansas, discussed in some detail the application of the cooperative method of instruction to engineering schools and

polytechnic institutes. As constituting five important factors governing the application of the cooperative method to any given institution, the author considered (1) the size, (2) geographical location, (3) type of location, (4) method of support, and (5) organization of the institution. He discussed various methods of applying the cooperative plan and expressed the opinion that "no exact conclusion can be drawn concerning the general principles governing the installation of the cooperative method at an institution since the controlling conditions are so different in each case."

Factors Affecting the Extinction of Short A-C. Arcs

The results of a study concerning the extinction of short a-c. arcs were discussed in a paper by T. E. Browne, Jr. of the Westinghouse Elec. & Mfg. Company, East Pittsburgh, Pa. Mr. Browne's findings as stated were:

1. That the arc space recovers the ability to withstand 100 volts or more within a few microseconds after a current zero, as predicted by Slepian's theory.

2. That the maximum allowable rate of voltage rise across the arc space which will just permit arc extinction, is much greater for very short arcs (1 cm. or less) than for longer arcs.

3. That the critical rate of voltage rise depends upon the electrode material and tends to vary as a decreasing linear function of the boiling point of that material.

4. That the higher-current arcs have a much lower critical rate of rise of voltage than the lower-current arc.

Vacuum Tubes Score Again

A corona-tube voltage regulator designed to accomplish all of the functions of the ordinary vibrating type of regulator, and without the mechanical difficulties incident to the latter, was described by H. W. Dodge of the New Jersey Bell Telephone Company, and C. H. Willis (M'28) of Princeton University. The authors presented and described a circuit wherein a corona tube is used to regulate the output of a full-wave rectifier, the rectifier in turn controlling the excitation of a generator to give constant voltage. They presented very attractive performance curves covering the application of the apparatus to a 5-kva. generator under varying load conditions. The authors characterized the regulator as employing the same methods of compounding and line-drop compensation now in use and expressed the belief that the simplicity, compactness, high sensitivity, and quick response of the regulator offered important advantages.

Lightning Surges Cause Arcing Faults

Experimental studies of arcing faults imposed on a typical 75-kv. transmission system were discussed in a paper prepared jointly by J. R. Eaton (A'27) of the Consumers Power Company, Jackson, Mich., J. K. Peck (A'27) of the National Electric Light Association, New York, and J. M. Dunham (A'31) of the American Telephone and Telegraph Company, New York. High-voltage impulses simulating lightning were imposed upon an energized transmission line to cause flashovers. As a result of their observations the authors concluded that the probability of a lightning flashover causing a power arc is increased when power current is flowing past the flashover point, when the normal frequency voltage is increased, or when the normal insulation is decreased.

Effective arc resistance was described as being approximated by the ratio of the peak voltage to the peak current, the apparent power factor of the arc current and voltage being practically unity in most cases. The tests showed that arcs formed in a capacitive circuit are more persistent than those in inductive or resistive circuits, and indicated an average peak of about 300 volts per foot of arc length, for currents of about 100 amperes or more. Regarding system overvoltages arising from arcing grounds, the authors concluded the maximum to be approximately three times normal peak voltage from line to ground, and that it occurs on a sound phase and most frequently during the first cycle of the fault.

Minutes of Annual Meeting Held at Asheville June 22

The annual meeting of the American Institute of Electrical Engineers was held at the Grove Park Inn, Asheville, N. C., as the opening session of the annual summer convention, Monday morning, June 22, 1931. President W. S. Lee presided.

The annual report of the board of directors was presented in abstract by F. L. Hutchinson, national secretary. Printed copies were distributed to members in attendance and are available to any member upon application to Institute headquarters, New York. The report, which constitutes a résumé of the activities of the Institute during the fiscal year ending April 30, 1931, shows a total membership on that date of 18,334. In addition to the three national conventions and five District meetings, 1,628 meetings were held during the year by the local organizations of the Institute in the principal cities and educational institutions in the United States, Canada, and Mexico. The report will appear in full in the Quarterly Transactions of the Institute.

The report of the committee of tellers on the election of officers of the Institute was presented, and in accordance therewith President Lee declared the election of the following members, taking office August 1, 1931:

President:

C. E. Skinner (F'12), assistant director of engineering, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.

Vice-Presidents:

W. B. Kouwenhoven (M'22), professor of electrical engineering, assistant dean of the Engineering School, Johns Hopkins University, Baltimore, Md.

W. E. Freeman (M'27), head, department of electrical engineering, assistant dean of College of Engineering, University of Kentucky, Lexington, Ky.

Paul H. Patton (M'25), telephone engineer, Northwestern Bell Telephone Company, Omaha, Neb.

A. W. Copley (F'26), engineering manager, Pacific Coast district, Westinghouse Electric & Mfg. Company, San Francisco, Calif.

L. B. Chubbuck (M'26), switching equipment engineer, Canadian Westinghouse Company, Ltd., Hamilton, Ont.

Directors:

L. W. Chubb (F'21), director of Westinghouse Research Laboratories, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.

B. D. Hull (M'26), engineer, Southwestern Bell Telephone Company, Dallas, Tex.

H. R. Woodrow (F'23), electrical engineer, Brooklyn Edison Company, Inc., Brooklyn, N. Y.

National Treasurer:

W. I. Slichter (F'12 and national treasurer), professor of electrical engineering, Columbia University, New York, N. Y.

(These officers, together with the following hold-over officers, will constitute the board of directors for the next administrative year, beginning August 1: W. S. Lee (retiring president), Charlotte, N. C.; Harold B. Smith (F'13 and past-president), Princeton, Mass.; H. V. Carpenter (F'18 and vice-president), Pullman, Wash.; G. C. Shaad (F'13 and vice-president), Lawrence, Kans.; I. E. Moultrop (F'29 and vice-president), Boston, Mass.; H. P. Charlesworth (F'28 and vice-president), New York, N. Y.; T. N. Lacy (M'24 and vice-president), Detroit, Mich.; J. Allen Johnson (F'27), Buffalo, N. Y.; A. M. MacCutcheon (F'26), Cleveland, Ohio; A. E. Bettis (F'26), Kansas City, Mo. (terms expire July 31, 1932); J. E. Kearns, Chicago, Ill.; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y. (terms expire July 31, 1933); A. B. Cooper (M'16), Toronto, Ont.; A. E. Knowlton (F'30) and R. H. Tapscott (F'29), New York, N. Y. (terms expire July 31, 1934).

President Lee then congratulated President-elect Skinner (F'12) upon his

ion and presented him with the ident's badge. Mr. Skinner re-ded with a brief address, which was usiastically received.

he report of the committee on award nstitute prizes, as published in the 1931 issue of ELECTRICAL ENGINEER-(p. 448) was read by A. E. Knowlton, rman of the committee of award, which the prizes were presented by ident Lee.

he Lamme medal for 1930, which, nnounced in the March 1931 issue of CTRICAL ENGINEERING (p. 230), had awarded to W. J. Foster (F'16), of enectady, N. Y., was presented.

he annual presidential address was delivered by President Lee, the ect being "Coordination—the Es-e of Modern Engineering." (This ress is published in full on p. 512 is issue.)

djourned.

(Signed) F. L. HUTCHINSON,
National Secretary

Who's Who n Engineering"

ngineers listed in the forthcoming ion of "Who's Who in Engineering" tly will receive notification of the upon which their listing occurs.

he publishers emphasize the fact that mes of this compendium of engineer-biographies will be available only to e placing reservations prior to publi-on, and urge prompt action on the of any persons wishing to acquire book.

itute Policy Committee Appointed

the May 19, 1931 meeting of the tute's board of directors the question raised—*should the Institute, with the t of enhancing the status of the engi-ng profession, devote more of its rces to non-technical activities, such, xample, as legislation, education, and conomic welfare of the engineer*?

he following resolution was adopted:

ESOLVED: That the president be authorized point a special committee on Institute es for the purpose of studying the present ny proposed future activities of the Insti-this committee to invite and consider stions from any member, officer, or committee, and to make definite recommendations to this board regarding modifications of present activities and plans for any additional fields of work that the committee may deem desirable."

In accordance with this action, President Lee appointed the following committee:

Chairman, C. E. Stephens (M'22) (vice-president and northeastern district manager, Westinghouse Electric & Manufacturing Company, New York, N. Y.) director; present chairman of finance committee; member, committee on coordination of Institute activities, executive committee, U. S. National committee of the I. E. C., and the assembly of American Engineering Council.

Vice-Chairman, H. A. Kidder (F'29) (superintendent of motive power, Interborough Rapid Transit Company, New York, N. Y.) past-vice-president; present chairman, committee on engineering profession; member, board of examiners, law committee, assembly of American Engineering Council, and board of trustees of United Engineering Trustees, Inc.

H. P. Charlesworth (F'28) (vice-president Bell Telephone Laboratories, Inc., New York, N. Y.) vice-president New York City District; past-chairman, meetings and papers committee; chairman, committee on coordination of Institute activities; member, Edison medal, engineering profession, finance, Lamme medal, meetings and papers, and publication committees, and board of trustees of United Engineering Trustees, Inc.

F. L. Hutchinson (M'13) (national secretary, A. I. E. E.) member, committee on coordination of Institute activities, Edison medal, and publication committees, assembly of American Engineering Council, engineering societies library board.

J. A. Johnson (F'27) (chief electrical engineer Buffalo, Niagara & Eastern Power Corporation, Buffalo, N. Y.) director; present chairman, membership committee; member, Edison medal, executive, electrical machinery, and research committees.

E. S. Lee (F'30) (assistant engineer General Electric Laboratory, Schenectady, N. Y.) present chairman, Sections committee; member, committee on coordination of Institute activities, and instruments and measurements committee.

E. B. Meyer (F'27) (vice-president United Engineers & Constructors, Inc., Newark, N. J.) director; past-chairman, meetings and papers, and finance committees; present chairman, law committee; member, committee on coordination of Institute activities, Edison medal, finance, publication, and power generation committees.

W. S. Rodman (F'28) (professor of electrical engineering, University of Virginia) vice-president, Southern District; student Branch counselor; member, Sections and electrophysics committees, education research committee of Engineering Foundation, and assembly of American Engineering Council.

C. F. Scott (F'25 HM'29) (head of department of electrical engineering Yale University), past-president; chairman, development committee 1919; member, Lamme medal, standards and student Branches committees, assembly of American Engineering Council; past-member, many other Institute committees.

This committee held its first meeting June 8 at Institute headquarters and directed that through this notice in ELECTRICAL ENGINEERING the membership be invited and urged to submit through the national secretary any suggestions or criticisms relating to the present activities of the Institute; also regarding any additional activities which individual members may deem desirable.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

COLLINOT, MARCEL A., 88 Sherman Ave,, Newark, N. J.
COLE, WILL G., Box 222, Westwood, Calif.
CORRIVEAX, F. M., General Electric Co.. Schenectady, N. Y.
FALK, VICTOR E., 2422 Euclid Ave., Cleveland, Ohio.
FYLER, GEORGE W., Y. M. C. A., Schenectady, N. Y.
MCDONALD, I. M., 772 Pollokshaws Road, Glasgow, Scotland.
NUBER, FRANK J., 3831 Rokeby St., Chicago, Ill.
O'SHEA, V., JR., 115 Broadway, New York, N. Y.
SULLIVAN, JOHN E., 6320 Kenmore Ave., Chicago, Ill.
TUNG, C. T., c/o Stone & Webster Engg. Corp., Hopewell, Va.

Personal

F. M. Feiker Appointed Commerce Director

The appointment of FREDERICK M. FEIKER (M'15) managing director of the Associated Business Papers, Inc., New York, N. Y., to the office of director of the Bureau of Foreign and Domestic Commerce was announced May 29, 1931, by President Hoover. Mr. Feiker succeeds W. L. Cooper who is withdrawing to resume his former duties as commercial attaché at London, England.

Born at Northampton, Mass., Mr. Feiker received his degree of B. S. in E. E. from Worcester Polytechnic Institute, Worcester, Mass., in 1904. He has served as editor of *Factory Magazine* and *Electrical World*; chairman of the editorial board of *System* and *Factory*; and vice-president of the McGraw-Hill Publishing Company, Inc., New York, N. Y. During 1920-21 he was Acting Assistant Secretary of Commerce and

served in the various capacities. Besides having been a member of the Institute for almost two decades, Mr. Feiker holds an active membership in the American Society of Mechanical Engineers and the Illuminating Engineering Society.

HAROLD B. SMITH (F'13) past-president of the Institute and for many years head of the department of electrical engineering Worcester Polytechnic Institute, Worcester, Mass., resigned his educational chair there effective June 1931. As one well known in engineering and education Dr. Smith always has carried forth a multiplicity of duties in these fields. His share in Institute activities has been abundantly represented by service on several of its committees simultaneously, including: law 1920-21; electrolysis and student branches 1920-27; instruments and measurements 1921-22; educational 1922-27; sections 1922-28; Edison Medal 1924-26, 1929-30, 1930-31; research, coordination of Institute activities, and meetings and papers 1924-27; code of principles for professional conduct 1928-29; executive 1929-31; and public policy 1930-31. He was appointed also to the John Fritz Medal board of award for 1929-33, the U. S. national committee of the I. E. C., the Chas. A. Coffin Fellowship & Research Fund committee 1929-30, and the American Engineering Council 1930-31. It is his hope to resume professional practise.

F. V. MAGALHAES (F'19) who left New York and his office as general superintendent of distribution and installation, New York Edison Company, to become vice-president of the Hall Electric Heating Company, Inc., now has been appointed general manager of his company in addition to his duties as vice-president. His professional career has been a busy one; during the past year he was vice-chairman of the Institute's committee on safety codes, an alternate representative for the Institute in the National Fire Protection Association (electrical department) and on the National Fire Waste Council; also a member of a special subcommittee of the standards committee dealing with reactive power. The year previous he served at various times as a member of the Institute's board of examiners and the meetings and papers committee; was member and chairman of the A. I. E. E. committee on instruments and measurements. For several years was one of the Institute's representatives to U. S. National committee of the International Electrotechnical Committee.

H. L. WILLS (A'20) inductive coordination expert as assistant to the vice-president and general manager of the Georgia Power Company, Atlanta, Ga., now has established a consulting engineering practise of his own, specializing in adjustment of relations between telephone, telegraph, railway signal, and automatic train control systems, including problems of electrolysis and radio interference. Mr. Wills was chairman of the Institute's Atlanta Section in 1921 and 1928, and has rendered much valuable service to the National Electric Light Association as a member of its inductive coordination committee (1923-27); chairman (1928-29). Mr. Wills has been active also in the association's joint operations with the Bell Telephone System (joint subcommittee on development and research, 1926-31) and with the American Railway Association's subcommittee on principles and practises (1929-31).

F. M. DENTON (F'28) head of the department and professor of electrical engineering, University of Mexico, Albuquerque, N. M. has been awarded fellowship in the City and Guilds of London Institute, the highest distinction that institute confers. Only eleven of its several thousand graduates since the inauguration of its Fellow in E. E. degree have received it; it was awarded to Mr. Denton as one "of a limited number of Associates (ACGI) with not less than five years of actual practise and having contributed to advancement of the industry." The City and Guilds College (School of the University of London) is said to be the foremost of engineering schools in the British Empire.

D. LEVINGER (M'30) engineer of manufacture, Western Electric Company, recently was elected one of its directors, the youngest member of the company's board. Already he has served the company for 21 years and now as its engineer of manufacture heads a large force of trained engineers and scientists. He is a member of the Institute of Mining and Metallurgical Engineers, and has served three years upon its research committee; he also is a member of the American Society of Mechanical Engineers, the American Society for Steel Treating, and the American Association for the Advancement of Science.

R. F. PACK (M'12) recently elected president of the Northern States Power Company has been identified with the electrical industry since 1891 when he engaged as office boy with the Toront Electric Light Company. He was in strumental in the affiliation between th Canadian Electrical Association and th National Electric Light Association i the affairs of which he has always re mained active. He worked with E Gherardi (F'12 and past-president) vice president of the A. T. & T., in improvin harmonious relations between these tw great industries.

T. H. CLEGG (M'21) who has bee affiliated with the Philadelphia Rapi Transit Company as special engineer, o June 1, 1931, opened his own consultin offices at the same address, 1600 Walnu Street, Philadelphia, Pa. In the past Mr. Clegg's work has been of a confi dential nature appertaining to powe investigations, and to the operation an management of power plants. For th past three years he has served th American Electric Railways Associatio on committees dealing with power con tracts and mercury-arc rectifiers.

C. E. SKINNER (F'12) assistant directo of engineering, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa. upon June 8, 1931, received the Lamm Medal annually awarded by Ohio Stat University to an alumnus "for meritori ous achievement in engineering or th technical arts." Mr. Skinner has don much conspicuous professional work i many fields of electrical application. H has served the American Society of Test ing Materials (1917-18), the Engineerin Council (1917-19), and American Engi neering Council (since 1923).

W. R. WHITNEY (A'01) vice-presiden and director of the research laboratory General Electric Company, Schenectady N. Y., was awarded the Franklin Medal o the Franklin Institute May 20, 193 The award, which this year took place a Philadelphia, is made annually to "work ers in physical science or technolog without regard to country, whose effort in the opinion of the administerin committee on science and arts, have don most to advance a knowledge of physica science or its application."

JOSEPH O. PHELON (M'13) for 44 yea identified with the Worcester Polytechni Institute, Worcester, Mass., retired fro the office of professor of electrical eng neering June 1931. For several yea after his graduation from that Institut he taught in its physics department, bu

1896 he was transferred to the newly rmed department of electrical engineer- g where he has served as full professor nce 1907 and as head of the department 1911-13. He now plans to make Cali- rnia his place of residence.

W. S. Gifford (A'16) president, merican Telephone & Telegraph Com- any, New York, N. Y. has been elected member of the board of trustees of ooper Union, New York City, to succeed homas Snell, deceased. This continues tradition of service to Cooper Union by en in the forefront of industry and ublic affairs.

W. F. Fenninger (M'22) who has been rving as supervisor of electric courses the Rochester (N. Y.) Mechanics Insti- te, is now state supervisor of technical id cooperative education, with head- uarters at Albany. In this capacity he sits the several high schools in which chnical courses are given offering sug- stions to bring them up to State andards or for maintaining these stand- ds if already achieved.

M. K. McGrath (M'27) who has been rving as vice-president of the Inter- tional Telephone & Telegraph Corpo- tion, Aldwych, London, W. C. 2, ngland, left there June 6, 1931, to take residence in America. His address for e present will be in care of the Inter- tional Telephone & Telegraph Corpo- tion, New York, N. Y.

L. C. Armitage (A'28) who has been dustrial heating engineer for the eneral Electric Company, Schenectady, Y. has now become designing engineer the Ajax Electric Company, Inc., at iladelphia, Pa. where his principal rk will be the design and development a variable temperature electric decorat- g kiln.

R. D. Bean (A'21) formerly manager the engineering development depart- nt of The Brown Instrument Com- ny, Philadelphia, has been made chief gineer of that company. Mr. Bean's tensive field investigations cover many plications of measuring instruments.

F. J. Airey (A'19) division manager the General Electric Supply Cor- ration at Los Angeles, Calif., has en elected chairman of the National ectric Wholesalers' Association. He s been 42 years in the business of ctrical merchandising.

B. L. Robertson (A'26) assistant professor of electrical engineering, Pennsylvania State College, State College, Pa., has left the East to enter the department of electrical engineering of the University of California at Berkeley, Calif.

H. C. Wolfe (A'28) recently has become associated with the Empire Industries, Inc., Cleveland, Ohio, as its president. His work with the company will be the development of industrial application of chromium plate for engine parts, turbine blades, molds, and various tools and dies.

R. D. McCarter (M'09) who has been doing a consulting engineering business in New York City, has joined the European Gas & Electric Company, Aldwych, London, W. C. 2, England.

Obituary

H. Eugene Chubbuck (F'13) retired operating head of the Illinois Traction System, Inc., whose name is closely linked with the story of electricity and its application, died June 4, 1931 in Peoria, Illinois, after an extended illness. He was born in Utica, New York, and educated in the public schools of that city supplemented by one year at Whitestown Seminary and later a special course in chemistry and physics. In 1880 he returned to Whitestown as instructor in these subjects. He devoted the years 1881-1883 to shop practise in telegraph and philosophical instruments, the last year for the greater part being spent on electric lighting and testing machinery. In 1883 he engaged with the Thomson Houston Company as an expert and installed the first lighting plant at Pawtucket, R. I. The Narragansett Electric Company of Providence, R. I. next appointed him as its electrical engineer, a service occupying him for one year, and terminating in his return to special expert and construction work for Thomson Houston. In 1898 he joined the General Electric Company for special work and was given charge of its sales offices at Salt Lake City. He was the son of A. S. Chubbuck and grandson of S. W. Chubbuck, both well known to the profession for establishing the manufacture of telegraph machinery, and the building of some of the first instruments used. Mr. Chubbuck joined the Institute as an Associate four years after its organization, when the grade of Associate was the compulsory initial grade.

T. H. U. Aldridge (F'18) vice-president and general manager of the Shanghai Power Company, Shanghai, China, died suddenly on the 10th of May, 1931. A native of London, England (1874), his residence in China dates back to 1901 when he accepted appointment as municipal electrical engineer to the International Municipal Council of Shanghai. By the end of 1916 his staff had increased from three Europeans and 120 Chinese to 76 Europeans and 1,099 Chinese. As engineer-in-chief and manager of the municipal electricity department Mr. Aldridge was directly responsible to the electricity committee for both technical and commercial direction of undertaking as well as matters involving finance. He was responsible also for the general design and layout of two large power stations including all essentials of a central station light, heat, and power system. During his régime the system was converted from single-phase, 100-cycle, 2,000-volt generation and distribution to a modern 50-cycle system. The annual report of the Shanghai Municipal Council's electricity department (1917) attests the success of his undertakings.

Carlyle Kittredge (F'22) assistant to the vice-president of the Michigan Bell Telephone Company, Detroit, Mich., and for many years its chief engineer, died in the Harper Hospital that city May 23, 1931, the result of an operation for acute appendicitis. He was born at Mason, Mich., July 19, 1874. As past-chairman of the Institute's Detroit-Ann Arbor Section (1921) he has been specially active for its interests. He also was a member of the Detroit Engineering Society. In 1897 he was graduated from the University of Michigan with the degree of B. S. in E. E., and two years later joined the Electric Light & Power Company, Van Wert, Ohio, as its superintendent. In 1900 he engaged with the Central Union Telephone Company, doing special inspection work in Ohio, Indiana, and Illinois, ultimately becoming assistant chief engineer. On August 15, 1911, he joined the Michigan State Telephone Company as plant engineer, a position which he held until 1920 when he became chief engineer. At the time of his death he was secretary of the Wolverine section of the Telephone Pioneers of America.

Jay L. Stannard (M'29) chief engineer of the department of public utilities, City of Tacoma, Washington, died March 13, 1931 having been ill less than a month. He was a native of Chittenango, N. Y. (1866); after two years in common and high school at Shell Rock, Iowa, he spent two years at Cornell

College, Mount Vernon, Iowa. Until 1887 his time was occupied chiefly with a civil engineering practise. For the next ten years he acted as engineer for the contractor on several of the power and lighting projects of the Pacific Coast. Prior to his arrival in Tacoma (1923) Mr. Stannard had been identified with many irrigation, water works, and power plant developments along the Pacific Coast; the Grant Smith Company project in California, the Cedar River plant at Seattle, and the Bull Run plant at Portland. From 1912 to 1919 he was consulting engineer for the North Coast Power Company in Portland. At the time of his death he was serving his second term as president of the Tacoma Section of the American Society of Civil Engineers, which he had been instrumental in establishing.

WILLIAM F. CALLAHAN (A'23) engineering assistant, Western Union Telegraph Company, New York, N. Y., died May 31, 1931, at the age of forty. After the completion of studies in machine design, manual training and applied electricity at Pratt Institute, his first business connection (1910) was when he joined the Western Electric Company, New York, with which he remained as machine hand and inspector until 1913; then he became draftsman of Bramhall Deane & Company, Brooklyn, N. Y. In March 1914 he engaged with the Western Union Telegraph Company, New York City, spending three years as draftsman, followed almost immediately by appointment as engineering assistant, the position he held until his death. Mr. Callahan belonged to the Institute's New York Section, in which he was active.

Mr. Alexander, winner of first prize, recently has won a Tau Beta Pi scholarship for $750 and a $500 tuition scholarship from the Massachusetts Institute of Technology. In his freshman year he received a $1,000 prize offered for the best paper by the American Chemical Society.

The following names of officers of the Oklahoma City Section for next year were announced: C. T. Almquist (A'28) associate professor of electrical engineering, University of Oklahoma, chairman; A. Naeter (M'30) head electrical engineering department, Oklahoma A. & M. College, vice-chairman; and C. E. Bathe (A'29), superintendent of radio and standards, Oklahoma Gas & Electric Co., secretary-treasurer.

Local Meetings

Utah Section and Branch Meet

The Utah Section and the University of Utah Branch held their annual joint meeting for the presentation of a student program on May 18. This was the last meeting of the Section for the present administrative year.

The following papers were presented by students:

KEYING OF CONTINUOUS-WAVE TRANSMITTERS, by M. R. Johnson and L. K. Irvine.

ILLUMINATION OF THE UNIVERSITY CAMPUS, by L. D. Schroder and J. O. Carlston.

STROBOSCOPIC EFFECTS WITH NEON GLOW TUBES, by Courtney Campbell.

INVESTIGATION OF THE ACOUSTICS OF KINGBURY HALL, by Fred Lundberg and F. M. Neal.

Oklahoma City Section Meets with Branches

The annual joint meeting of the Oklahoma City Section and the student Branches at the University of Oklahoma and the Oklahoma A. & M. College was held at the latter school on May 18, 1931. During the morning program students of the two schools presented the following technical papers:

CHOICE OF PETROLEUM PUMP STATION EQUIPMENT, by V. J. Sittel, Oklahoma A. & M College.

FACTORS DETERMINING THE RATING OF UNDERGROUND CABLES, by Wm. M. Achgill, A. B. Bartow, T. A. Bloss, University of Oklahoma (presented by Wm. M. Achgill).

GROUNDS AND METHODS OF TESTING THEM, by Hubert I. Short, Oklahoma A. & M. College.

SYSTEM SOLUTION BY THE METHOD OF SYMMETRICAL COMPONENTS, by R. J. Thompson, University of Oklahoma.

THYRATRON TUBE AND ITS RECENT APPLICATIONS, by W. E. Nichols, Oklahoma A. & M. College.

RADIO FIELD INTENSITY SURVEY, by G. S. Hammonds, University of Oklahoma.

TRANSMISSION LINES: GENERATOR-END REQUIREMENTS VERSUS LOAD CONSTANTS, by P. H. Foster, Oklahoma A. & M. College.

APPLICATION OF KIRCHOFF'S LAWS AND SUPERPOSITION OF CURRENTS IN CALCULATING LOOP AND NETWORK CIRCUITS, by S. Alexander, University of Oklahoma.

The program was followed by a luncheon (attended by about 115) and the inspection of engineering laboratories.

At an afternoon session authors of three papers were awarded prizes as follows:

First prize ($15) S. Alexander, University of Oklahoma

Second prize ($10) Waldo E. Nichols, Oklahoma A. & M. College

Third prize ($5) Hubert I. Short, Oklahoma A. & M. College

Section and Branch Join in Meeting at Cincinnati

The annual joint meeting of the Cincinnati Section and the University of Cincinnati Branch was held at the university on May 14, with an attendance of 80; the preceding dinner was attended by 38.

The following program was presented by seniors in electrical engineering:

CHOKE-COIL DESIGN, by D. T. Michael.

STUDY OF A SPOT WELDER, by F. F. Osterholz.

STUDY OF A 500-CYCLE GENERATOR, by G. H. Pettibone.

EXPERIMENTAL STUDY OF MEANS OF LESSENING STATIC IN RECEIVING SETS, by G. F. Platts.

SPEED CONTROL OF A D-C. MOTOR, by R. M. Seitz.

PITTING IN TELEPHONE RELAY CONTACTS, by Henry Suter.

Baltimore Section Awards Prizes

Each alternate year the Baltimore Section has a prize paper meeting. For the contest this year six papers were submitted for three of which the following prizes were awarded at this meeting:

First prize: ($25)—W. P. Taylor, Consolidated Gas Electric Light and Power Company. LOCATING POWER CABLE FAULTS BY MEANS OF A CONSTANT CURRENT TRANSFORMER WITH SHORT CIRCUITING SWITCH.

Second prize: ($15)—L. J. Berberich, graduate student, Johns Hopkins University, A METHOD FOR MEASURING THE PHASE ANGLES OF SHIELDED RESISTORS.

Third prize: ($10)—G. M. L. Sommerman graduate student, Johns Hopkins University THE SPARK DISCHARGE IN AIR.

e speakers were invited to an execu-
linner preceding the regular meeting.
following officers were elected for
year 1931-32; chairman K. A.
ey (M'12) chief engineer Locke
ator Corporation; vice-chairman
. Smith (M'25) assistant to general
intendent, Consolidated Gas Elec-
ight & Power Corporation; secretary-
urer J. Wells (A'27) development
ger Western Electric Company.

day Discoveries
elebrated at Lehigh University

honor of the centennial of Faraday's
very of electromagnetic induction,
neering students at Lehigh University,
lehem, Pa., under the leadership of
ocal student Branch of the Institute,
a special joint meeting April 29, 1931.
bers of the several engineering
ties at Lehigh presented papers
iptive of different phases of Fara-
scientific work and staged apparatus
nstrations designed to commemorate
day's more important discoveries.

ght students cooperated in the
aration and presentation of five
s as follows:

Faraday the Man, by F. W. Matchett,
'31.

Contribution to Chemistry, by R. C.
Chem. '31 and L. S. Millelot, Chem. '31.

Contribution to Metallurgy, by
Wagner, Met. E. '31 and J. S. Harrison,
E. '31.

Electromagnetic Induction, by R. E.
r, E. E. '31 and L. R. Wanner, E. E. '31.

Optics, by D. L. MacAdam, Engg.
cs '32.

ast
ction Meetings

n

me Engineering Features in Con-
ion with Heavy Construction, by
Lee, president, A. I. E. E. Illus-
d by several reels of motion pic-
Dinner meeting. Election of
rs for 1931-32: R. R. Krammes,
man; R. A. Hudson, secretary; P. C.
, treasurer. May 22. Attendance

Boston

Annual meeting and election of following officers: C. A. Corney, chairman; F. D. Hallock, vice-chairman; G. J. Crowdes, secretary-treasurer. Motion pictures and other entertainment remainder of the evening. May 14. Attendance 121.

Cincinnati

W. Weftendorp, General Electric Company, spoke on the study of the light penetration and its detection through fog. A representative of the Army Air Corps of Dayton outlined Army preparedness plans with particular reference to obtaining materials and construction for airplanes. Dinner preceded the meeting. May 5. Attendance 250.

Annual golf tournament and dinner preceded the evening meeting at which Prof. F. H. Bird, University of Cincinnati, spoke on Economic Phases of City Development. Election of officers: E. S Fields, chairman; J. A. Noertker, secretary-treasurer. June 4. Attendance 46.

Connecticut

Annual outing and dinner dance. May 23. Attendance 115.

Dallas

Lead Storage Batteries and the Fundamental Principles of Battery Operation and Maintenance, by W. E. Dunn, Electric Storage Battery Company. Election of officers: Gibbs A. Dyer, chairman; S. M. Sharp, secretary-treasurer. May 25. Attendance 104.

Denver

Business meeting. May 12. Attendance 17.

Detroit-Ann Arbor

The Electrical Industry and Electrical Engineering in Soviet Russia, by A. Dovjikov, Westinghouse Elec. & Mfg. Company. Prior to this talk many members inspected the Moore's Park station of the City of Lansing. May 19. Attendance 200.

Erie

Vacuum Tubes, by A. W. Hull, General Electric Company. Election of officers: P. R. Urich, chairman; C. V. Roberts, secretary. May 19. Attendance 83.

Houston

Storage Batteries, by W. E. Dunn, Electric Storage Battery Company. J. S. Waters elected secretary. May 26. Attendance 15.

Indianapolis-Lafayette

Vacuum-Tube Control, by S. D. Fendley, General Electric Company. May 15. Attendance 94.

Iowa

Railroad Electrification Developments in America and Abroad, by F. W. Peters, General Electric Company. Joint meeting with the Des Moines Engineers Club and the Des Moines Architects Club. Election of officers: H. B. Hoffhaus, chairman; E. W. Schilling, secretary-treasurer. May 14. Attendance 90.

Ithaca

Election of officers: W. E. Meserve, chairman; B. K. Northrop, secretary-treasurer. Dinner meeting. May 29. Attendance 13.

Lehigh Valley

Annual meeting and exhibition at which applications of the photoelectric cell, metering equipment, and other recent electrical developments were displayed by various manufacturers. Preceding dinner the following motion pictures were shown: "Dynamic America," "The Romance of Power," "Deion Oil Circuit Breakers." Reports from the chairmen of the local committees were read and officers for the year 1931-32 were announced. Planning to Avoid Depressions, by E. C. Stone, vice-president A. I. E. E. District No. 2, was presented by R. L. Kirk, Duquesne Light Company. May 16. Attendance 135.

Los Angeles

Two papers concerning the R. C. A. 50-kw. broadcasting transmitter being installed for KFI, were presented by J. J. Farrell and G. W. Fyler, both of the General Electric Company. Election of officers as follows: P. S. Biegler, chairman; F. E. Dellinger, secretary. Joint meeting with the Institute of Radio Engineers. May 19. Attendance 203.

Louisville

Annual meeting. Reports of local committees were read, and election of officers was made as follows: Philip P. Ash, chairman; C. M. Ewing, secretary-treasurer. Dinner and entertainment followed. June 4. Attendance 37.

Memphis

Power Plant Generation and Utilization, by Robert Bruce, Memphis Power and Light Company;

The New 110-Kv. River Crossing, by M. Eldredge, Memphis Power & Light Company, and chairman, Memphis Section. May 12. Attendance 42.

Fuseless Home, by H. G. Nichols, Westinghouse Elec. & Mfg. Company. June 9. Attendance 36.

Milwaukee

Inspection trip through the Globe-Union Mfg. Company plant, and talk by W. R. Vicarey of that company on

"Sparks from a Lifetime with Batteries." May 6. Attendance 280.

Air Law, by Professor Carl Zollman, Marquette University Law School. Election of officers: Carl H. Kreuger, chairman; E. U. Lassen, secretary. Dinner meeting. June 3. Attendance 32.

Niagara Frontier

Safety, by W. S. Sterne, president, Safety Club. This talk was concluded by a motion picture film on Lux fire extinguishing equipment especially applied to oil fires;

Some Phases of Industrial Economics, by Dexter S. Kimball, dean, College of Engineering, Cornell University. Informal dinner preceded the meeting. May 15. Attendance 60.

Philadelphia

Lightning Arresters and Their Application, by E. Beck, Westinghouse Elec. & Mfg. Company. May 11. Attendance 175.

Pittsburgh

The Characteristics and Applications of Grid-Glow Tubes with Demonstrations, by D. D. Knowles and S. P. Sashoff, both of Westinghouse Elec. & Mfg. Company. Demonstration of grid-glow tubes. Buffet luncheon served after the meeting. Joint meeting with the Engineers' Society of Western Pennsylvania. Election of officers: F. A. Connor, chairman; Thomas Spooner, secretary-treasurer. May 12. Attendance 276.

Rochester

Radio Interferences, by H. J. Klumb, Rochester Gas & Electric Company. Joint meeting with the Institute of Radio Engineers. Election of officers: Frederic C. Young, chairman; C. F. Estwick, vice-chairman; E. K. Huntington, secretary-treasurer. May 29. Attendance 36.

San Francisco

The Electric Propulsion of Ships, by Captain C. S. McDowell, U. S. Navy. Election of officers for year 1931-32: E. A. Crellin, chairman; E. F. Maryatt, vice-chairman; W. C. Smith, secretary. This meeting was held on board the *U. S. S. Pennsylvania*, and those present inspected the ship at the conclusion of Captain McDowell's address. May 15. Attendance 300.

Seattle

Papers presented by Section members were as follows:

Analysis of Distribution Substation Costs, by A. Shipek;

Industrial Electronic Tubes, by L. B. Robinson;

Electric Light—King and Servant Supreme, by George Boyd;

General-Purpose Synchronous Motors and Control, by R. B. Lane. A prize of $25.00 for presentation of the best paper was awarded A. Shipek. Election of officers: M. T. Crawford, chairman; A. F. Darland, vice-chairman; C. B. Carpenter, secretary-treasurer. May 19. Attendance 52.

Sharon

Oxygen—The Wonder Worker, by G. E. Harke, Air Reduction Sales Company. Illustrated by moving pictures and demonstrations of liquid oxygen. Election of officers: R. M. Field, chairman; A. M. Wiggins, secretary-treasurer. June 2. Attendance 130.

Toledo

Radio Supervision, by J. E. Brown, U. S. Department of Commerce. The lecture was followed by an inspection trip to the Toledo Police, Radio, and Fire Alarm Building. May 22. Attendance 150.

Washington

Some Notes on Engineering in Electric Utility Operation, by J. J. Ferry, Potomac Electric Power Company. Election of officers: G. L. Weller, chairman; T. J. MacKavanagh, vice-chairman; C. M. Brown, secretary-treasurer. May 12. Attendance 88.

Past Branch Meetings

University of Arizona

Benjamin Garver Lamme, by H. P. McGovern, student. May 15. Attendance 5.

Television, by T. Phillips, student. Election of officers: P. F. Hawley, chairman; F. Phillips, vice-chairman; T. S. Henderson, secretary-treasurer. May 22. Attendance 6.

University of Arkansas

Cathode-Ray Oscillograph, by A. Bost, student;

Studies in Lightning Protection, by Prof. W. B. Stelzner, counselor. Election of officers: Harold D. Albrecht, chairman; H. G. Thomasson, vice-chairman; Robert Vining, secretary; Paul Johnson, treasurer. May 13. Attendance 16.

Armour Institute of Technology

Methods of Testing Radio Rece ers, by R. K. Pew, United Air Clea Corporation. May 15. Attendance

Election of officers: W. L. Jost, cha man; T. A. McGill, vice-chairman; R. Frye, secretary, G. L. Bonvallet, treasur May 29. Attendance 65.

Brooklyn Polytechnic Institute

Engineering Education Subseque to Graduation, by John C. Parker, vi president, Brooklyn Edison Compa May 7. Attendance 40.

Electro-Anesthesia, by A. E. Cro student;

Turbine Power in Ships, by R. Bue student. Two films shown,—"Big Deed and "Hydroelectric Power." May Attendance 20.

Bucknell University

Discussion of methods of increasi Branch activities. Farewell meeting the senior members; luncheon was serv thereafter. May 20. Attendance 9.

California Institute of Technology

Some Edison Company Devel ments, by R. J. C. Wood, South California Edison Company, Ltd. El tion of officers: Patrick B. Lyons, cha man; Paul F. Arnerich, vice-chairma Robert W. St. Clair, secretary-treasur May 21. Attendance 45.

Case School of Applied Science

Election of officers: W. J. Latt president; W. J. Cherney, vice-preside K. R. Spangenberg, secretary; M. Ferguson, treasurer. April 30. Att dance 89.

Clarkson College of Technology

Election of officers: Charles O. McNai chairman; Joseph H. O'Rourke, secreta William E. Lehner, treasurer. April Attendance 59.

Inspection trip to the Massena pl of Aluminum Company of Ameri April 27. Attendance 15.

Clemson Agricultural College

Election of officers: H. S. Montgome chairman; H. C. Woodson, vice-chairm C. A. Farish, secretary. May 14. tendance 32.

Colorado State Agricultural College

Film—"Wizardry of Wireless." El tion of officers: Leroy Sweet, preside Alfred Holden, vice-president. May Attendance 10.

University of Denver

Business meeting. May 7. Att dance 15.

Life of Faraday, by L. C. Grussle

-Faraday Developments, by I.
ch;
ical Faraday Experiments, by
ssell;
er Developments, by E. R.
tner. After these talks the labora-
were open for inspection. May 22.
dance 60.
tion of officers: L. C. Grussler;
Gaerttner, vice-president; Irwin
ich, secretary-treasurer. May 26.
dance 15.
n—"Turbine with Solid Rotor."
. Attendance 16.

rsity of Detroit

rth annual banquet held at the
ac Athletic Club. Election of
s: Bernard Sharkey, chairman;
ufal, vice-chairman; John Schenk,
ary; Thomas M. Ward, treasurer.
. Attendance 60.

rsity of Florida

asurement of Ground Resis-
s, by A. W. Harris, student. May
Attendance 25.

rd University

e Queenston-Chippawa Power-
lopment, by R. Bullwinkle, student;
blic Utilities, by Eric A. Walker,
t;
e A. I. E. E. North Eastern Dis-
Meeting at Rochester, by J. H.
t, student. Election of officers:
A. Walker, chairman; Robert D.
k, Jr., vice-chairman; Charles N.
, secretary-treasurer. May 19.
dance 14.
pection trip to the toll exchange of
ew England Telephone and Tele-
Company, Boston. May 21. At-
nce 10.

State College

tion of officers: W. L. Huebner,
ent; W. Hardman, vice-president;
nks, secretary; M. Cain, treasurer.
2. Attendance 21.

s State College

tion of officers: G. E. Cain, presi-
D. E. West, secretary. May 14.
dance 100.

n University

: History of the Electrical
try, by J. M. Bisbee, student;
velopments in the Electrical
in 1930, by J. F. Miller, student;
ution of Lightning Problems, by
Sponsler, student. Election of
s: L. F. Underwood, president;
Brown, vice-president; J. J. Grine-
reasurer; C. W. Banks, secretary.
3. Attendance 40.

Institute

iness meeting. Prof. F. A. Rogers
ated for counselor. May 1. At-
nce 15.

Inspection trip to the plant department of the American Tel. & Tel. Company. June 3. Attendance 17.

How I Got into Engineering, by A. B. Smith, Automatic Electric Company. June 5. Attendance 68.

Michigan State College

Illustrated talk given by F. Harbin, student, featuring a film entitled "Radio Communication on Trains." May 12. Attendance 23.

Several talks by students and a demonstration of the "Telemat." Joint meeting with the University of Michigan Branch. May 28. Attendance 32.

To Find the Maximum Span of a Catenary if the Density, Tensile Strength, and Gravity Remain Constant, by L. Switzgable, student;

Discussion of the Effect of Division of Load upon Rotary Converter Systems, by G. T. Hittle, student. Explanation of the recording interferometer given by Prof. C. W. Chamberlain. June 9. Attendance 29.

University of Michigan

Business discussion. May 13. Attendance 16.

Annual banquet at which the following program was presented:

Joseph Henry, by L. C. Poole, student;

A Russian Meets a Turk, by P. D. Kalachov, student;

Michael Faraday, by L. Zanoff, student;

The Hand is Quicker than the Eye, by Prof. A. D. Moore;

Before the Drought, by Dean Emeritus M. E. Cooley. May 26. Attendance 60.

School of Engineering of Milwaukee

Life of Steinmetz, by J. D. Ball, vice-president of the school. May 13.

University of Minnesota

Tenth biennial electrical engineers' party. April 17-18. Attendance 4,100.

Banquet meeting. Election of officers: Martin G. Swanson, chairman; Harold L. Ericson, vice-chairman; Scott McDermott, secretary-treasurer. May 19. Attendance 33.

Mississippi A. & M. College

Election of officers: J. M. Caldwell, chairman; C. R. Lillybridge, vice-chairman. May 20. Attendance 27.

University of Missouri

The Possibilities in Engineering, by R. V. Wright, president of A. S. M. E. Joint meeting with the A. S. M. E., A. S. C. E., and A. I. Ch. E. April 30. Attendance 43.

Audible Light, by J. B. Taylor, General Electric Company. May 18. Attendance 176.

Montana State College

Transformer Design, by R. Bjork, student;

Volta Power Plant, by N. Hovey, student;

Black Eagle Plant, by T. Micka, student. May 14. Attendance 99.

The Electrical Show at Washington State College, by W. Rightmire, student;

The Impedance Bridge, by P. O. Koetitz, student;

Office Illumination, by R. Rydell, student. May 21. Attendance 94.

University of Nebraska

The Lincoln Telephone & Telegraph Company's first aid team gave a demonstration covering the high points of first aid work. May 13. Attendance 45.

University of Nevada

Election of officers as follows: Donald Knapp, chairman; Calvin Dodson, vice-chairman; Orvis Reil, secretary-treasurer. May 3. Attendance 21.

University of New Hampshire

Moving pictures and talks by E. J. Shaw and L. M. Shampeau, both of the Westinghouse Elec. & Mfg. Company. May 6. Attendance 56.

Talk by W. S. Keay, New England Gas & Electric Association. May 20. Attendance 80.

Business meeting. May 27. Attendance 16.

University of New Mexico

Smoker. Economics of Neon Lighting, by E. Huffman and H. Mendenhall, students. H. Bangerter and S. Pelatowski, students, gave a demonstration of some of the effects of ultra-short radio waves. May 28. Attendance 21.

College of the City of New York

Transmission of Power, and High-Voltage Insulators, by Mr. Wildebrandt, Ohio Insulator Company. May 21. Attendance 15.

University of North Carolina

Engineering in the Latin Countries, by Professor Bennett. May 14. Attendance 23.

North Dakota State College

Radio Broadcasting, by D. F. Holaday, student;

Magnetism, by B. Weiss, student;

Michael Faraday, by E. Blomquist, student;

Some Actual Experiences, by R. Stockstad, student;

Life After Graduation, by Professor H. Rush, counselor;

Relations of Industry to College Men, by J. D. Taylor, Northwestern

Bell Telephone Co. May 27. Attendance 15.

University of North Dakota

PHOTOELECTRIC CELLS AND APPLICATIONS, by Eugene Becken, student;

THE INSTITUTE AND ITS FUNCTIONS, by Prof. H. F. Rice, counselor. May 13. Attendance 28.

University of Notre Dame

Annual picnic. May 16. Attendance 160.

THE MARVELS OF SOUND TRANSMISSION, by S. P. Grace, assistant vice-president, Bell Telephone Laboratories, Inc. May 19. Attendance 1,300.

Ohio Northern University

Banquet meeting. ELECTRICAL ENGINEERS IN INDUSTRY, by Prof. A. D. Moore. Election of officers: O. R. Jacobs, president; B. Wyant, vice-president; W. Gideon, secretary; O. Hawes, treasurer. May 29. Attendance 75.

Ohio State University

Demonstrations were performed by the students using the new equipment just acquired for the electrical engineering department. May 1. Attendance 60.

Ohio University

THE LARGE DIFFERENCES WHICH ARE MADE BY THE LITTLE DIFFERENCES IN MEN, by Dr. E. B. Bryan, president of the University. Election of officers: George Wyckoff, chairman; William Miller, vice-chairman; William Cooper, secretary-treasurer. May 6. Attendance 41.

Oregon State College

SUBMARINE CABLES, by E. D. Pearson, North Western Electric Company. S. B. Clark, of the same company, supplemented this talk by describing the manufacture of submarine cables. Election of officers: Dale Hansen, president; Elliott MacCracken, vice-president; George Howie, secretary; Stewart Kibbe, treasurer. May 12. Attendance 71.

Pennsylvania State College

REPORT OF OSCILLOGRAPHIC STUDIES OF THE SOURCES OF COMMUTATOR RIPPLES IN D-C. MACHINERY WITH PARTICULAR REFERENCE TO THE ROTARY CONVERTERS, by Messrs. Conrad, Forster, Foster, and Pollock, students;

REPORT OF CAPACITOR INDUCTION MOTOR STUDIES, by Messrs. Henderson, Kennedy, Lauth, and Sauter; students;

DEMONSTRATION OF THE STROBOSCOPIC POSSIBILITIES OF THE NEON LAMP, by W. W. Harris, student.

Illustrated lecture on ALASKAN SALMON FISHERIES, by Prof. B. L. Robertson. May 18. Attendance 40.

Purdue University

Two films shown—"Voices Across the Sea" and "By-Products of a Telephone Research Laboratory." Election of officers: P. O. Peterson, president; M. W. Brown, vice-president; E. M. Sharer, secretary; G. K. Miller, treasurer. May 15. Attendance 30.

Rhode Island State College

Business meeting. May 27. Attendance 6.

Rice Institute

Election of officers: M. E. Kattmann, chairman; H. A. Martin, vice-chairman; E. A. Turner, Jr., secretary; R. C. Bearmann, treasurer. May 13. Attendance 20.

University of South Carolina

ALEXANDER GRAHAM BELL, by W. O. Farnam, student;

SOUND WITH PICTURES, by R. L. Phillips, student;

SILVER SELENIDE WITH A SECRET METAL USED BY A GERMAN TO GET ELECTRICITY FROM SOLAR RAYS, by J. T. Sanders, student;

THE X-RAY—NEW WATCH-DOG OF SAFETY, by J. B. Dent, student. May 18. Attendance 31.

Annual banquet. May 16. Attendance 16.

THOMAS ALVA EDISON, by W. E. Crum, student;

THE VARIABLE MU TETRODE, by J. W. Palmer, student;

A SOUTH CAROLINIAN—W. S. LEE, by C. D. Caughman, student. May 11. Attendance 29.

University of Southern California

RECENT DEVELOPMENTS IN THE ELECTRICAL INDUSTRY, by W. F. Grimes, Westinghouse Elec. & Mfg. Company. April 22. Attendance 23.

CHAIN BROADCASTING, by Paul Johnson, Pacific Tel. & Tel. Co. April 29. Attendance 26.

APPLICATION OF ELECTRICITY IN THE OIL FIELDS, by C. J. Ruzicka, Standard Oil Company. May 6. Attendance 26.

LAYOUT OF SUBSTATIONS ON THE 220-KV. DISTRIBUTION SYSTEM OF THE EDISON COMPANY, by J. M. Gaylord, Southern California Edison Company, Ltd. May 13. Attendance 26.

H. M. Cox, Bureau of Power & Light, gave instructions on artificial respiration and some useful hints on first aid, with special reference to burns which might be received by an electric current. Election of officers: M. C. Marshall, chairman; John Ganzenhuber, vice-chairman; Louis Bayha, secretary; Oliver Jessen, treasurer. May 20. Attendance 28.

DEVELOPMENT OF THE U. S. MOTORS CORPORATION, by W. M. Hogne, of t company. May 27. Attendance 31.

Stanford University

LIFE AND WORK OF MICHAEL FARAD by G. W. Dunlap, student;

EXPERIENCES AT THE GENERAL EL TRIC TEST COURSE. by M. Born, s dent. May 19. Attendance 12.

RESIDUAL CURRENTS AND VOLTA IN ELECTRICAL POWER SYSTEMS, G. H. Kimball and C. A. Bairos, studer June 2. Attendance 10.

Election of officers: Madison R. Jon Jr., chairman; G. W. Dunlap, vice-cha man; Ronald H. Born, secretary-tr surer. June 5.

University of Tennessee

MERCURY VAPOR LAMPS, by H. DuBo student. Election of officers: H. Patterson, chairman; G. L. Dyer, vi chairman; C. T. Nunley, secreta treasurer. May 5. Attendance 13.

University of Texas

RESEARCH AND INDUSTRY, by E. Manning, General Electric Compa Joint meeting with the A. S. M. E. a A. S. C. E. April 22. Attendance 60

THEORY AND APPLICATIONS OF EL TRIC RELAYS, by H. P. Robins Houston Power & Light Company. M 15. Attendance 23.

Virginia Polytechnic Institute

Election of officers: R. E. McDan chairman; M. W. Bowery, vice-chairm May 29. Attendance 20.

West Virginia University

LIGHT BEAMS TO OPERATE TRAF SIGNALS, by C. E. Higgins, student;

THE DU PONT AMMONIA PLANT CHARLESTON, W. VA., by H. A. Lev student;

SAFETY AT NIGHT FOR THE AVIATOR, V. S. Monteith, student;

YOUR NIMBLE SERVANT—THE EL TRON, by P. J. Johnson, student. M 5. Attendance 15.

Washington State College

THE VACUUM-TUBE VOLTMETER, Mr. Emigh, student;

SHORT CIRCUITS ON MAIN TRA MISSION LINES, by Mr. Holmes, stude May 8. Attendance 13.

Washington University

General discussion. May 14. Att dance 18.

University of Wisconsin

Film—"Electrical Measuring Inst ments." April 28. Attendance 40.

Business meeting. May 26. Att dance 20.

Employment Notes

of the Engineering Societies Employment Service

en Available

NGINEER, E. E. degree, age 30, married. e experience in layout, design, and research mall electrical parts, radio, motion picture sound system apparatus. Desires position boratory or drafting room. A-1 references. ilable immediately. Location, New York. 38.

RADUATE MECHANICAL-ELECTRI- ENGINEER, married. Nine years in ic utility, testing, substation construction. year with consulting engineer. Eight years rical engineer, central department for group arge industrial plants; layout, operation, er distribution, economy. Three years rical, process engineer, manufacturing t; development, efficiency, supervision. ellent references. East preferred. Avail- short notice. C-9312.

EVELOPMENT AND RESEARCH GINEER, B. S. in E. E., M. S. in physics, married. Four years' experience in one of st research laboratories in electromagnetic lems and measuring instruments, knowledge adio-frequency circuits and vacuum tubes, patents granted, high designing and rvising skill. Desires position with future. 33.

HIEF ELECTRICIAN AND MANUFAC- RING ENGINEERING ASSISTANT, nical graduate, 34. Fourteen years' ex- nce covering electrical installation, opera- and maintenance, and the manufacturing nechanical and electrical parts. Desires ion as plant electrician, testing of electrical hinery or apparatus, or engineering assis- . Moderate salary to start. Location, thern New Jersey or vicinity. C-9305.

RADUATE ELECTRICAL ENGINEER Purdue University with eighteen years' rience in design, construction, estimating, , valuation and appraisal of power plants, tations, transmission lines and industrial ts including five years in heavy electric ion and rapid transit work. Open for rtunity with future. C-8256.

LECTRICAL ENGINEER, 1930 graduate, single. One year on the Westinghouse ent Course. Desires position as instructor ctrical engineering. Available school year -1932. References. Location, immaterial. 11.

LECTRICAL CONSTRUCTION ENGI- ER, age 45; 25 years' experience. Has oad technical knowledge, and extensive tical experience in commercial and industrial r and lighting construction including under- nd, power house and substation installations railway electrification work. Has a ough knowledge of estimating and valuation and the supervising of construction forces. 40.

LECTRICAL ENGINEER, 27, single, uate of German college, six years' experi- in design, research, and test on magnets, ional horsepower motors, and control ms for mine hoists and elevators with ng American and German concerns. De- position where knowledge of theoretical ractical is of importance. C-9310.

ELECTRICAL AND ILLUMINATING ENGINEER, 42 years old, 23 years' experience, electrician, superintendent, estimator, engineer, instructor. Power station, commercial and industrial building wiring, etc. Seven years in engineering for architects, office buildings, theaters, hotels, schools, hospitals, industrial buildings. Would like engineering position, or sales engineering. C-8460.

ELECTRICAL ENGINEER, graduate, E. E. degree, 28, married. Three years' experience relays, relay studies of large electric power and light utility, operating, New York City. Three years testing, design, and development work on new electrical appliances and materials. Experience includes considerable outside contact with leading electrical manufacturers. Available immediately. Location, New York City. B-8793.

ELECTRICAL ENGINEER, American. Street railway, main-line electrification, mining, and public utilities. Twenty years in Latin America as engineer and manager. Did considerable Diesel-engine and refrigeration work. B-5912.

ELECTRICAL ENGINEER, graduate Georgia Technology, 1930, cooperative plan. Westinghouse lighting courses. Cooperative work, alternate months, five years in substation maintenance and office engineering. Rebuilding transformers, switches, lightning arresters, work with electric furnaces, rectifiers, meters, motors, etc. Checking and mapping distribution systems, work orders, drafting, etc. Excellent references. Perfect health. Location immaterial. C-7847.

EXPERIENCED ELECTRICAL ENGINEER, graduate of two colleges, with twenty years of accomplishment in the electrical wire and cable industry; American, Protestant, and in good health. Would prefer to locate within 100 mi. of New York, though not essential. Can come for interview promptly; all references desired. B-9877.

MECHANICAL-ELECTRICAL ENGINEER, 46, single, 23 years' experience. Factory test, central station engineering, and sales work. Public utility operating engineer, assistant superintendent, and superintendent of construction, power and electric departments. Estimate and design work on substations, stations, relay systems, and lines. Specifications for buildings. B-271.

ELECTRICAL ENGINEER, 48, college graduate, married; 26 years' experience as designing, report, power and executive engineer with three engineering and construction firms, including system planning, design, construction cost estimating and construction supervision of power plants, substations and transmission facilities for public utilities and industrials. Studies of operating economics. B-4553.

ELECTRICAL ENGINEER, 26, single. Three years' experience with construction company, specializing in new construction. One and a half years' experience in light current work with leading telegraph company. Desires connection with company in construction or sales engineering departments. Location, New York City preferred. C-9290.

EXECUTIVE ELECTRICAL ENGINEER, 29, married. Six years' experience in design, and construction of transmission lines and substations. Now district manager for electrical manufacturing concern. Desires to make change. Available immediately. Location, immaterial. C-9324-315-C-4-San Francisco.

COLLEGE TRAINED ENGINEER, 29, married. Experienced in the design and estimating of distribution systems. Nine years' utility experience in responsible position. One and a half years' power cable engineering. Desires position with New York City utility, engineering or industrial company. Excellent references. C-9361.

HEAD OF ENGINEERING DRAWING DEPARTMENT of prominent university for seven years, will consider change to similar position. Available June 1931. B. S. in electrical engineering. Telephone and electrical experience. Practical machine designer. B-8248.

ELECTRICAL ENGINEER, graduate of University of Illinois, 1926. Two years' experience with Westinghouse, and two and a half years with public utility in planning division. Available immediately. C-9381.

GRADUATE ELECTRICAL ENGINEER, 29, married. One year eight months, Westinghouse test. Two and a half years' electrical construction with utility, engineering, supervision and reports. One year three months with consulting engineers. Desires position in planning department of public utility. No preference in location, C-7695.

ENGINEER, age 27, B. S. three years and seven months C. E. experience, desires position with hydroelectric project. Qualified for chief of party, transitman, estimator, assistant engineer. C-9382.

GRADUATE ENGINEER, age 35, two years' shop experience, fourteen years as draftsman in design of mechanical and electrical apparatus. Graduate of mechanical and electrical engineering courses of International Correspondence Schools. Willing to accept drafting or engineering position anywhere. C-9387.

EXECUTIVE OR STAFF ASSISTANT, engineering education. Fourteen years' broad experience with manufacturing, utility,. and industrial surveys covering cost reduction, production planning, standards, wage incentives, scientific management methods, statistical control systems, expense and cost analysis. Capable organizer. Profitable assistant for busy executive. Prefers East. Consider any proposition. B-9122.

COMMUNICATION ENGINEER, 31, single. Experienced: telephone, radio installations· design, development of testing equipment for telephone, radio, sound-picture circuits; design, use of semi- and full-automatic testing circuits to eliminate human element in testing; industrial applications of photoelectric cells, thermionic tubes. Best references as to professional ability, personal integrity. Location, immaterial. Available immediately. C-9376.

ELECTRICAL ENGINEER, age 29, married, Pennsylvania State graduate 1925, with four years' railroad and subway signal installation experience as engineer. draftsman, and signalman, and one and a half years as assistant project engineer on railroad electrification; desires position in either of these lines. Location, anywhere. C-5089.

A-C. DESIGN ENGINEER, induction, and synchronous motors above 20 hp., alternators and auto-transformers. Experienced in the application of synchronous motors to compressor drive. Married. Location, immaterial C-9386.

PHYSICIST, middle-aged, experienced in industrial research, supervision of research, executive work, and teaching physics for engineering and other classes of students. Advanced degrees in physics from prominent Ameri-

can universities. Emphasis of electrical subjects in training and teaching. Stability and opportunity desired. Available on short notice. C-7900.

ELECTRICAL ENGINEER, EXECUTIVE, FOREMAN, 25 years' sound practical, technical, electrical and mechanical manufacturing experience in telephone and telegraph apparatus, instruments, printing machines, and pressed metal. Capable organizer and supervisor. Works and office system, estimating, cost analysis and accounts. Methods, tool design, machine and press-work, time-study rate-setting, moderate salary. Any location. C-3241.

DESIGN ENGINEER, twenty years' experience in design of a-c. machines covering polyphase induction motors of all sizes. Single-phase induction motors with inductance or capacity starting. Single-phase commutator motors of series, repulsion, and repulsion-induction type. Desires design or development work. Location, immaterial. C-8540.

1931 GRADUATE ELECTRICAL ENGINEER, B. E. E. University of Minnesota. Single, age 22. Special courses taken include design, radio and telephone. Desires position with any manufacturing or engineering firm. Location immaterial, opportunities and experience being main factors. Available immediately. C-9391.

INDUSTRIAL PRODUCTION MAN, electrical engineer, married, age 29, good health, graduated 1924, seven years' experience with large construction company on design, engineering, and construction of power and industrial plants. Wants production department job where electrical training and experience will count, with possibility of working into management. Location, New England. C-9384.

ELECTRICAL OR MAINTENANCE ENGINEER, 48, married, college graduate, 22½ years with present employer. Plant sold to large organization with its own engineers. Unusual experience in installation and operation of industrial substations, large synchronous motors, replacing 25 with 60 cycles and maintenance. Good mechanical, steam and process development experience. C-9399.

ELECTRICAL ENGINEER, B. S. degree, married, with about fifteen years' successful experience in the design and construction of transmission and distribution lines. Some teaching experience. Employed at present. Desires position as instructor in electrical engineering subjects or physics and mathematics. Excellent references. Location preferred, Middle West or West. C-9339.

ELECTRICAL ENGINEER, 27, single, B. S. E. E. Six months Westinghouse Graduate Student Course. Two years' laboratory work circuit interrupters, large power rectifiers, one and a half years' development work on standard magnetic controllers for steel mill applications, handling negotiations, estimating on motor-control apparatus. Familiar French language. Available immediately. Location, preferably East. C-9393.

ELECTRICAL ENGINEER, 36, single, citizen, desires position with engineering, manufacturing, or public utility concern. Six and a half years' experience in power plant and substation design. Two years in electrical furnace work. Highest education. Additional G. E. engineering course. Speaks foreign languages. Available on short notice. C-2710.

1929 ELECTRICAL DESIGN ENGINEER, 24, B. S. degree technical school. One year Westinghouse Student Course. Motor, transformer, turbo test experience. One year large synchronous motor design. Six months Westinghouse electrical design school. Desires position, design, research, development work with manufacturing company, or engineering department power company. Single with dependents. Location, immaterial. References. Available immediately. C-9410.

GRADUATE ELECTRICAL ENGINEER, Lehigh University (1930), married, 25, ten months engineering graduate student at Westinghouse, 22 summer months with National Tube Company. Desires position with public utility or manufacturing company where analytical and research ability is prime prerequisite. Available on two weeks' notice. Location, East or Middle West. C-9395.

1931 ELECTRICAL GRADUATE, midwest university, 22, single. Tau Beta Pi student. Desires connection with manufacturing or public utility concern. Location preferred, Middle West. C-9398.

ELECTRICAL ENGINEER, graduate Georgia Technology, 1930, age 23, married, now employed by large industrial corporation. Desires position with public utilities or with small industrial, United States or foreign. Available on short notice. C-9396.

ELECTRICAL ENGINEER, 31, married, college graduate, with six and a half years' experience consisting of: oil circuit breaker design; electrification of industrial plants; operation, maintenance and electrification of ore mines and steel mills. Thoroughly experienced on motor applications, transformer stations, switchboards, and distribution systems. Last one and a half years as electrical engineer with steel company. C-9414.

ELECTRICAL ENGINEER, 30, married, A. B. '22, B. S. in E. E. '24 (Harvard). G. E. Test, transformer design, development and technical writing; experience in factory planning, has taught evening classes; speaks German. Location preferred, East. C-9402.

ELECTRICAL ENGINEER, draftsman, experienced designer of light and power layouts of generating substations (indoor and outdoor) office buildings, factories and air ports. Technical school graduate and fifteen years' practical experience in the electrical and mechanical industry. C-7979.

REPRESENTATIVE available. Experienced sales engineer, electrical engineer, graduate. Desires high-grade electrical line of utility or heavy-duty industrial equipment. Eastern location. B-4067.

ELECTRICAL ENGINEER, 36, university graduate, married. Twelve years with large public utility as cadet, inspector and electrical tester (motors, transformers, cables, and electrical appliances). Also one and a half years' research on combustion control apparatus for instrument manufacturer and some engineering sales experience. Desires position with future near Philadelphia. References. C-8350.

ELECTRICAL ENGINEER, 1928 graduate of a recognized university, 26, single. One year central station testing, twenty months special apprentice on a large electrified railroad and seven months' telephone experience. Seeks engineering position where the above training and experience can be applied, free to locate anywhere. C-9112.

GRADUATE ELECTRICAL ENGINEER, S. B. from M. I. T. in 1927. Accidental injury has prevented employment. Now recovered. Has done considerable study since graduation in electrical engineering and physics, particularly radio and acoustics. Interested in most any kind of connection. Available at once. Single, age 25. C-9205.

SALES ENGINEER, distinctly electrical background, has good sales record, profit-minded, 39, single, likes people and contacts. Seeks permanent connection with leadin company manufacturing controls for industri applications. Conversant with thermoelectri and photoelectric principles. Specialized know edge of conductors. Decided interest in di tribution in broadest sense. Has prove executive ability. C-8797.

TECHNICAL GRADUATE, 32, with broa experience in operation, maintenance of sub stations, cable network, electric shovels. Sub station testing. Speaks five languages. Desire connection with responsible company. Loca tion, immaterial. B-9611.

ELECTRICAL ENGINEER, 36, married 18 years' experience on power plants, transmis sion lines, substations, switchboards. Tele phones, mine electrical equipment, motors lighting, marine electrical work, draftsman Five years electrical engineer wiring for power light, telephones, signal systems, elevator for all types of buildings; also expert plumber heater and tinner. C-9348.

GRADUATE ELECTRICAL ENGINEER married, age 27, one year Westinghouse Studen Course, two years' production control; tw years' maintenance engineering. Desires per manent position with future. Will conside anything. Location, immaterial. C-9425.

GRADUATE ELECTRICAL ENGINEER 1929, 22, single; 15 months on General Electri Test Course. Desires position with utility o manufacturing company or with concern doing consulting or construction engineering. Avail able immediately. Location, New England preferred. C-8028.

1931 GRADUATE ENGINEER, single age 23. B. S. in E. E. from Lafayette College Ten months' experience as assistant engineer with large belting company. Three months radio coil test. Prefers engineering position with engineering company or manufacturing company. Best of references. Location, im material. Available immediately. Slight knowledge of Spanish. C-9422.

GRADUATE ELECTRICAL ENGINEER B. E. E. degree, 1930, 24, single; eight months on Westinghouse course. Assignments covered motor apparatus testing and refrigeration development work. Desires position with manu facturing concern or public utility. Working knowledge of Spanish. Initial salary and loca tion secondary to opportunity. Reference Available on short notice. C-9428.

GRADUATE ELECTRICAL ENGINEER age 28, married, with eight years' experience in industrial plant construction and maintenance railway electrification; power-plant design estimating, and construction. Supervisory experience on construction and costs with con tractor. Desires position with utility, manufac turer, or contractor, where ability to handle labor and produce results is a prerequisite C-4428.

RECENT GRADUATE, 23, Pratt Institute in Industrial electrical engineering. Four years' practical experience in installation work and operation of substations. Specialized in motor control. Desires position with power company or related work in manufacturing or construction. Location, immaterial. C-9176.

ELECTRICAL-MECHANICAL ENGINEER, married, seven years' experience includ ing G. E. Test, substation, and distribution with utility, development with electrical manu facturer, superintendent of small shop and operation of substations and motor rooms with a steel mill. C-1068.

MOTOR DESIGNER, graduate electrical engineer, 33, married, experienced in design of a-c. and d-c. motors and generators. Available immediately. C-8553.

LECTRICAL ENGINEER, 27, Italian. S. Harvard University, Dr. Eng. University Rome, exceptional theoretical and research nding, five years' experience best firms trical communication in Italy, United States erica, Germany, England. Desires position design or research work in Europe, England ntinent. C-9431.

LECTRICAL ENGINEERING TEACH- B. S. and M. S. in E. E., G. E. Test, en years' teaching experience with recogd technical school. Desires permanent tion. Available September. Excellent rences. Age 36. C-5807.

LECTRICAL ENGINEER with fifteen rs' experience in design, construction, reports editorial work. Available for publicity or orial work on trade publications. Refer- es with leading engineering and publishing s can be furnished. B-4022.

LECTRICAL ENGINEER, technical ge graduate, age 35. Ten to twelve years' hanical and electrical experience in power ts substations, transmission and distribu- systems. Work includes G. E. Test and lic utility engineering and operation. ires position on operating staff of power pany. Location, not particular. B-9782.

RADUATE ELECTRICAL ENGINEER, Eighteen years' experience in the manuure of electrical wiring devices, including gning, development, testing, estimating, and production work. Four years with erwriters' laboratories in charge of a branch e making inspections, tests, examinations, reports. Desires position with manufacng concern, inspection bureau or experital laboratory. C-8449.

LECTRICAL ENGINEER, 37, single, c. Eng. London University 1920. Six rs with British Thomson-Houston Comy. Two years with power company in nsylvania. Three years with General Elec- Company. Five years war service. Avail- at once. Any location. C-2248.

LECTRICAL ENGINEER, one year's erience test course. Three years' experience smission engineering department of large ern electrical manufacturer. Desires posi- with utility company, teaching. Thorhly familiar power system short-circuit, ility analyses, theory, application of method symmetrical components. B. S. E. E. versity of California 1927, 24, married. ilable July first. C-9437.

LECTRICAL ENGINEER, B. S. in E. E., 30, married. Manufacturing and test erience. Public utility transmission and disution engineering experience. Sales experie. Executive and teaching ability. Salary ected, open to offer. Position desired, open ffer. Available at once. C-7867.

LECTRICAL ENGINEER, 28, married, years out. One year power utility course, e years telephone and talking pictures. vious experience as commercial radio opera- Would be valuable to concern requiring able engineer. Position must be permanent n future. Location not a guiding factor. t of references are available. C-7902.

LECTRICAL ENGINEER, 30, married, duate 1924. Two years' postgraduate work, anced electrical theory, two and a half rs' writing specifications for the manufacture installation of telephone repeater offices, year at generator design and two years as engineer for public utility. Desires position a future. C-951.

LECTRICAL ENGINEER, B. S. in E. E., le, age 27. Five years' experience with electrical manufacturer on the development, design, and application of lightning arresters. Also close contact with lightning field investigations of recent years; familiar with this work and its results. Position with operating company preferred. C-9449.

TEACHER OF ELECTRICAL ENGINEERING, 37; married. Thirteen years' teaching experience; many summers spent in practical work. B. S. in E. E. and E. E. degrees. Taught all electrical engineering subjects as well as physics, electric thermodynamics, descriptive geometry, mechanical drawing. Sixteen months' general management large college radio station. Available immediately. C-9445.

ELECTRICAL ENGINEER, E. E. graduate 1924, age 29, married. One year telephone maintenance, two years General Electric Test, one year research, four years system operator large public utility. Experienced radio installation and maintenance. Desires position along line of experience with advancement opportunities. Location preferred, vicinity of greater New York. Available now. C-4182.

ELECTRICAL ENGINEER, 22, single, university graduate '31. Desires junior position in test or design departments of power machinery manufacturing concern. Experience limited. Location preferred, East. Available on short notice. C-9447.

ELECTRICAL ENGINEER, graduate 1931, single. Three years' cooperative experience in public utility maintenance work. Four summers' experience in ice-cream industry. Desires opening offering steady work and possibility of advancement. Location and type of work secondary. Available at once. C-9418.

ELECTRICAL ENGINEER, class '31, from a southern technical institute desires a part or full-time position as instructor in mathematics or electrical engineering with the privilege of carrying graduate work. C-9415.

1931 GRADUATE ELECTRICAL ENGINEER, age 26, industrious, reliable, Russian and American education seeks permanent connection. Location, immaterial. C-9455.

ELECTRICAL ENGINEER, 43, married, twenty years' electrical, power, and industrial plants experience in construction, maintenance of distribution, and transmission lines. Desires position with public utility or industrial plant. Can qualify as electrical superintendent. Used to handling men. Available on short notice. Canada preferred but would consider other location. C-9459.

ELECTRICAL ENGINEER, B. S. E. E. '30, age 22, single. One year General Electric Test. Desires position in either sales or operating department of public utility, or in any electrical line offering a future. Location, immaterial. Available at once. C-9454.

GRADUATE IN ELECTRICAL ENGINEERING, 1931, age 26, single, has B. S. in E. E. One year of electrical testing with large utility company. One year of electrical drafting of power and control switchboards. Three years' work in practical electricity. Interested in construction and supervision of small plants. Available at once. Location, anywhere. C-9457.

JUNIOR ENGINEER, 1931 graduate, B. S. E. E., University of Alabama. Desires position with utility, construction, manufacturing company. Location, immaterial. Experienced in power-plant and building installation and industrial control, having been employed for eight summer months and one full year, first as electrician helper and later as first-class electrician. C-9446.

RAILROAD ELECTRICAL ENGINEER, college graduate; A. I. E. E., A. S. M. E. A. E. R. A., A. R. A. membership; six years' design, construction, and operating experience on two large American railroad electrifications; familiar with American and European practises regarding motive power, substations, catenary, transmission lines. Excellent references: young. Desires position with consulting firm, railroad, power company, or manufacturer. C-8463.

GRADUATE in electrical engineering, class of '29, 25 and single; fourteen months G. E. Test. Four months' experience in research. Desires position in engineering department of utility or manufacturing company offering a future. Available at once. Location, eastern United States. C-9003.

ELECTRICAL ENGINEER, 32, technical graduate, twelve years' experience with public utilities; familiar with operation, design and construction of transmission lines, substations, steam and hydro-generating stations. Familiar with field and office work. Desires responsible position with holding company, operating company or consulting engineer. Location, immaterial. Available immediately. C-6401.

ELECTRICAL ENGINEER, 36, married, technically trained, fifteen years' experience covering complete engineering design, supervision of power plants, high-voltage switching stations, substations, transmission lines, including estimates, specifications, purchase of equipment, supervision of construction. Experience covers system development, investigations of systems for load conditions, expansion, relay and stability studies, frequency and load control. C-7194.

ELECTRICAL ENGINEER, E. E. from European electrotechnical university, M. S. from University of Michigan; 9 years' experience with public utilities in construction, maintenance, and design; three years with Westinghouse switchboard department, including engineering school; desires position of designing engineer with public utility or large industrial concern. C-4976.

ELECTRICAL ENGINEER, 22, single. E. E. degrees, 1929; M. S. in E. E. from M. I. T., 1931; 20 months' General Electric Test course. Desires position involving electric design and development or as instructor in electrical engineering. Location preferred, East. Available immediately. C-9462.

JUNIOR ENGINEER, 1930 graduate, B. S. degree in E. E., associate member of Sigma Xi. Eight months' practical experience in research, design, and testing with large radio concern. Desires position as engineering instructor or in any electrical line offering a future. Eastern location preferred. Salary secondary to opportunity. C-9300.

SALES ENGINEER, 36, married, graduate electrical engineer, fifteen years' experience, includes sale signal and telephone apparatus, control and charging equipment, light machinery and its design. Also field supervision, organizing, technical writing, engineering building projects, layouts, specification writing, estimating, teaching, lecturing. Available within two weeks. Location, vicinity New York City. B-247.

ELECTRICAL, STEAM, AND MECHANICAL SUPERVISOR, 33, married, twelve years' experience in industrial and power plants. For the past four years has had charge of all steam and electrical power and maintenance of large industrial plant consuming 4,000 kw. and 1,200 hp. steam. B-7004.

GRADUATE ELECTRICAL ENGINEER, 30, married. Seven years' practical experience

in design and construction of substations, electric distribution both overhead and underground, with relay application, industrial power layout, lighting design, familiar with the latest developments in these lines. Available immediately. B-6384.

ELECTRICAL ENGINEER, bachelor and master degrees; fourteen years' peculiarly broad experience in test, research and development, standardization, consultation, university teaching, executive work, personnel; familiar with both power and radio equipment and practise. Stability and opportunity primary; initial salary and location secondary. Available at once. C-4591.

COLLEGE GRADUATE, 27, single, B. S. in E. E. Eighteen months General Electric Test, 22 months telephone equipment engineer. Desires position in manufacturing or utility company. Location preferred, Middle West; however, not essential. Available at once. C-9285.

Membership

Recommended for Transfer

The board of examiners, at its meeting of June 5, 1931, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

MOWBRAY, WILLIAM J., cons. elec. engr., Cranston, R. I.

WELLER, GEORGE L., equip. and bldgs. engr., The Chesapeake & Potomac Tel. Co., Washington, D. C.

To Grade of Member

ASHMORE, JOSEPH, dist. mgr., British Elec. Repairs, Ltd., Birmingham, Eng.

BIEGEL, EARL J., asst. supt. elec. dist., Memphis Pwr. & Lt. Co., Memphis, Tenn.

BOROKHOVICH, JOHN A., asst. engr., Brooklyn Edison Co., Brooklyn, N. Y.

CLARK, EDWIN E., asst. prof. of elec. engg., South Dakota State School of Mines, Rapid City, S. D.

EVERITT, WILLIAM L., assoc. prof. elec. engg., Ohio State University, Columbus, Ohio.

GRAHAM, ROBERT W., asst. elec. supt., Bethlehem Steel Co., Buffalo, N. Y.

GRISCOM, SAMUEL B., central sta. engr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

HAINES, THOMAS H., supt. maint. of lines dept., Edison Elec. Illuminating Co. of Boston, Mass.

HARTMAN, HOWARD W., design engr., General Elec. Co., Schenectady, N. Y.

HELLERN, BERNHARD, production engr., National Industri, Drammen, Norway.

JONES, EVAN R., transm. engr., Mountain States Tel. & Tel. Co., Denver, Colo.

KAIGHN, HERBERT E., cons. engr., Wilmington, Del.

KLEIN, HARRY R., Jr., engr., Brooklyn Edison Co., Inc., Brooklyn, N. Y.

LAKE, MARSHALL E., pwr. sales engr., Duke Power Co., Charlotte, N. C.

MIER, C. WALKER, engr., Southwestern Bell Tel. Co., Oklahoma City, Okla.

MILBURN, LOYAL R., asst. elec. engr., Great Lakes Steel Corp., Detroit, Michigan.

MOREHOUSE, ADEN K., toll service supervisor, Pacific Tel. & Tel. Co., Portland, Ore.

OVEROCKER, RANDALL H., asst. engr., New Jersey Bell Tel. Co., Newark, N. J.

PURDY, HARRY E., engg. asst., Brooklyn Edison Co., Brooklyn, N. Y.

SPOONER, HOWARD M., field engr., United Engineers and Constructors, Inc., Newark, N. J.

STEBBINS, FREDERICK O., engr., General Elec. Co., Schenectady, N. Y.

YERKES, EARLE P., engineer of equipment, Bell Telephone Co. of Pa., Philadelphia, Pa.

YOUNG, HADLEY E., supt., East Canada Creek Hydro Sta., New York Power & Light Corp., Little Falls, N. Y.

ZEBLEY, JUNE S., supervisor of inspectors, Elec. Dept., Dist. of Columbia, Washington, D. C.

Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the secretary before July 31, 1931.

Balliett, C. G., Rochester Telephone Corp., Rochester, N. Y.

Balmford, J. A. (Member) Columbia University, New York, N. Y.

Barksdale, G. R. (Fellow) Tennessee Electric Power Co., Chattanooga, Tenn.

Brobson, J. F., Detroit Daily Mirror, Detroit, Michigan

Bulkley, O. R., Southern California Edison Co., Long Beach, Calif.

Clark, J. H., Southern California Telephone Co., Los Angeles, Calif.

Cline, J. E., Southern Indiana Tel. & Tel. Co., Seymour, Indiana

Eliason, W. L., Ontario Paper Co., Ltd., Thorald, Ont., Canada

Ennis, A. G., Philadelphia & Reading Coal & Iron Co., Pottsville, Pa.

Finfer, Sidney, Police Department, City of New York, New York City, New York

Finley, R. F., New York Central Lines, New York, N. Y.

Foernsler, L. O., 11113-113th St., Richmond Hill, N. Y.

Gray, L. T., Jr., Pacific Gas & Electric Co., San Francisco, Calif.

Hansen, F. A. (Member) Holophane Co., Inc., Los Angeles, Calif.

Hery, V. D., Index Machinery Corporation, Cincinnati, Ohio

Karle, J. J., Kny-Scheerer Corp., Long Island City, N. Y.

King, C. J., Montaup Electric Co., Somerset, Mass.

Korik, C. (Member) Home Engineering Co., Philadelphia, Pa.

Lee, A. C. (Member) Duke Construction Company, Durham, N. C.

Long, W. F., Union Electric Light & Power Co., St. Louis, Mo.

Mallory, D. D., Valparaiso University, Valparaiso, Indiana

Miller, T. H., 1575 Washington Street, San Francisco, Calif.

Mitchell, I. A., Kenyon Transformer Co., Inc., New York, N. Y.

Mowry, C. H., The New York Telephone Co., Brooklyn, New York

Murray, J. S. (Member) Follansbee Brothers Co., Follansbee, W. Va.

Neuschot, R. (Member) Thompson-Starrett Co., Inc., New York City, N. Y.

Nicol, W. C., Hartford Steam Boiler Inspection & Insurance Co., Chicago, Ill.

O'Handley, J. A., Western Electric Co., Kearny, N. J.

Rathbun, V. R., Dept. of Public Utilities, Tacoma, Wash.

Reynolds, F. N. (Member) General Electric Co., Philadelphia, Pa.

Robinson, F. W., Stanton Oper. Co., Pittston, Pa.

Ruddell, L., Kansas City Power & Light Co., Kansas City, Mo.

Schwabacher, G. P., General Electric Co., Bridgeport, Conn.

Seaman, F. D., Dominion Electric Power Ltd., Regina, Sask., Can.

Smith, C. C., General Electric Co., Bridgeport, Conn.

Steates, E. F., 11 Clark Place, Utica, New York

Stevens, O. L. Erie County Electric Co., Erie, Pa

Stilwell, W. E., Jr., Union Gas & Electric Co., Cincinnati, Ohio

Stone, R. D., State Trade School, Willimantic, Conn.

Stretch, M. W., Westinghouse Elec. & Mfg. Co., Mansfield, Ohio

Thomson, G. T., Hydro Electric Power Commission of Ont., Leaside, Ontario, Canada

Van Horne, J. C., Powell, Wyoming

Wannag, V. E., Western Electric Co., Kearny, N. J.

Welch, W. M., Bell Telephone Co. of Penna., Philadelphia, Pa.

Wold, T., Smith & Stone, Ltd., Georgetown, Ont., Canada

45 Domestic

Foreign

Barnes, H. W., Ferranti Ltd., Aldwych, London, Eng.

Ganpathi, R., The Cochin Electric Co. Ltd., Cochin, South India

Cheryan, P. C., Siemens-Schuchert-Werke A. G., Berlin, Germany

Phillips, F. A., Electrical & Radio Service Co., Hurstville, Australia

Ram, A., Renala Hydro Electric Installation, Renala Khurd, Dist. Montgomery, Punjab, India

Roth, A., Kabelfabrik und Drahtindustrie Aktien-Gesellschaft, Vienna, Austria

Shinohara, K., Ministry of Communication, Tokyo, Japan

Taylor, M. G., c/o Venezuela Power Co., Ltd., Barquisimeto, Venezuela, S. America

8 Foreign

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during May are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

FACHAUSDRÜCKE DER SCHWEISSTECHNIK. Deutsch-Englisch-Russisch. Berlin, V. D. I. Verlag, 1931. 31 pp., 6 x 4 in., paper, 2-r. m.——This little dictionary is intended to supplement the general engineering dictionaries by providing a list of the welding terms in general use, especially those of recent coinage. The book has been compiled by the welding committee of the German Engineering Society and is unusually successful in providing exact equivalents for the terms.

MACMILLAN TABLE SLIDE RULE. By J. P. Ballantine. N. Y., Macmillan Co., 1931. Tables, 11 x 9 in., paper, $.50.——A set of four numerical tables and four slides, by means of which the arithmetic problems that arise in trigonometry and engineering may be solved without calculation. The charts answer the purpose of an ordinary slide rule. Three to four places can be read direct; five or more may be had by interpolation.

RECORDING SOUND FOR MOTION PICTURES. Edit. by Lester Cowan for the Academy of Motion Picture Arts and Sciences. N. Y., McGraw-Hill Book Co., 1931. 404 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth. $5.00.——A textbook upon the technique of making sound pictures, prepared by a number of experts. The equipment for recording and reproducing sound is described in detail, as are also the manipulation of the film and the problems of studio acoustics and of recording. The book is the first to present a systematic account of practise in its field.

MECHANICAL LABORATORY METHODS. 4th edit. By J. C. Smallwood and F. W. Keator. N. Y., D. Van Nostrand Co., 1931. 386 pp., illus., diagrs., charts, tables, 10 x 6 in., cloth, $3.50.——Directions are given for testing and calibrating scales, calorimeters, brakes, fluid meters and other instruments, for analyzing fuels and determining their heat value, and for testing engines, boilers, pumps, refrigerating machinery, lubricants and electrical machinery. The principles underlying the methods are given, and the directions are clear and concise. This edition has been revised and rearranged to conform with modern requirements.

SPONS' ELECTRICAL POCKET-BOOK. By W. H. Molesworth. Lond., E. & F. N. Spon; N. Y., Spon & Chamberlain. 4th edit., 1931. 401 pp., diagrs., charts, tables, 7 x 4 in., leather, $2.50.——Small enough to be carried in a coat pocket, this work of some 400 pages contains a careful selection of material frequently needed for reference by engineers, particularly those engaged in central station work, transmission and railroading.

Theory and Practice of RADIO FREQUENCY MEASUREMENTS. 2nd edit. By E. B. Moullin. Lond., Charles Griffin & Co., Ltd.; Phila., J. B. Lippincott Co., 1931. 487 pp., illus., charts, diagrs., tables, 9 x 6 in., cloth. $12.50.——A practical laboratory guide covering all the measurements usually made and giving clear, detailed methods for making them. The new edition has been almost doubled in size and largely rewritten.

Selected Items From Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 2,000 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translations of foreign articles at cost.

Ammeters

HIGH FREQUENCY. A Method of Comparing Ammeters At Very High Frequencies, C. L. Fortescue and L. A. Moxon. *Sci. Instruments—Jl.*, vol. 8, no. 3, Mar. 1931, pp. 94-97, 5 figs. Considerable difficulty has been experienced in comparing ammeters at frequencies above one million cycles per second with reasonable degree of accuracy; means of overcoming these difficulties are described and final arrangement is reliable up to frequencies of 100 million to within accuracy of 2 per cent.

Brushes

COMMUTATOR. Double Brush-Holders Improve D-C. Machine Operation, A. M. Harrison. *Power*, vol. 73, no. 15, Apr. 14, 1931, pp. 586-587, 3 figs. Under certain conditions use of double brush-holders on d-c. machines is advantageous, while on other machines they may be objectionable.

Cables

PAPER INSULATED. The Manufacture of Lead-Covered Paper-Insulated Telephone Cable, J. R. Shea. *Mech. Eng.*, vol. 53, no. 4, Apr. 1931, pp. 277-283, 17 figs. Particulars regarding new developments comprising direct application of wood-pulp insulation, improved cable stranding, vacuum drying, and central melting of large quantities of lead alloy and its distribution through piping to number of sheathing presses. Before "Three-M" (Management, Materials, Maintenance) Congress, Cleveland, Ohio.

RUBBER INSULATED. Ueber Maschinen zur Herstellung von Kabeln (Machines for Manufacture of Cables), M. Pollman. *Gummi-Zeitung*, vol. 45, nos. 21 and 22, Feb. 20, 1931, pp. 876-877 and Feb. 27, pp. 914-916, 7 figs. Particulars of so-called wire-covering machines of both vertical and horizontal type for covering of thin and thick conductors. See reference to previous articles by author in same journal, in Engineering Index 1930, p. 545, and Engineering Index 1929, p. 603.

SUBMARINE. Some Economic Factors in the Design of Single Core Submarine Cables for Carrier Telephony, J. R. Vezey. *Elec. Communication*, vol. 9, no. 4, Apr. 1931, pp. 217-221, 4 figs. Having decided on length, attenuation, and number of speech channels for any cable, relative proportions of weights of central conductor, dielectric and return conductor to obtain lowest cost can be varied over wide range; further feature, brought out by study, is that maximum length of cable over which it is possible to work fixed number of channels, varies relatively little within limits of practical sizes of core.

TELEPHONE. Buried Tape-Armored Exchange Cable, C. W. Nystrom. *Telephony*, vol. 100, no. 14, Apr. 4, 1931, pp. 22-25, 10 figs. New method of underground exchange construction applicable to suburban residential areas; method and materials used in burying tape-armored exchange cable; cable placed in either hand or machine-dug trench.

Circuits

HIGH-VOLTAGE. A Note on the Timing of Electrically Independent Transient Circuits for High-Speed Oscillographic Work, L. B. Snoddy and J. C. Street. *Gen. Elec. Rev.*, vol. 34, no. 4, Apr. 1931, pp. 258-259, 3 figs. Method for initiating discharge in high-voltage circuits at definite time has been developed and applied to lightning generator voltages up to 430 kv.; method uses combination of over-voltage and irradiation by ultra-violet light; it has advantage that it requires no electrical connection between tripping circuit and high-voltage side of impulse circuit.

Circuit Breakers

ELECTRIC. Oil-Less Switchgear. *Elecn. (Lond.)*, vol. 106, no. 2760, Apr. 24, 1931, pp. 611-612, 3 figs. Siemens-Schuckert works and A. E. G. have, as result of experimental work in their laboratories, put on to market high capacity oil-less switches, thus showing their confidence in methods by which they have tackled problem; switches of both these types were on view at Leipzig Technical Fair.

Conductivity

The Electrical Conductivity of Some Bismuth Alloys at Low Temperatures, J. C. McLennan, J. F. Allen and J. O. Wilhelm. *Roy. Soc. Canada—Trans.*, vol. 24, pt. 1, section 3, May 1930, pp. 25-32, 1 fig. Investigation to find how superconducting point of lead would be affected by alloying this metal with bismuth and with antimony; also to determine superconducting point of some of fusible alloys of which bismuth is constituent. Bibliography.

Control

CHEMICAL PLANTS. Centralized Control Improved Production, A. J. A. Peterson, *Instruments*, vol. 4, no. 2, Feb. 1931, pp. 51-53, 2 figs. Large chemical plant in Niagara Falls applied to its problem of machine and load control, same principles used in central station industry; in this plant, operator must control and supervise 10 to 14 manufacturing units, all forming heavy electrical loads, and must supervise incoming supply as well.

ELECTRIC HEATING. Radiation-heating Control, C. G. Heys Hallett. *Elec. Rev.*, vol. 108, no. 2785, Apr. 10, 1931, pp. 626-627, 4 figs. Remarkable economies in current consumption and gains in personal comfort result from use of radiation thermostat or "Eupatheostat" as compared with ordinary air thermostat.

Controllers

Misapplications of Control Equipment, H. C. Jenks. *Indus. Eng.*, vol. 89, no. 3, Mar. 1931, pp. 110-113, 4 figs. Putting control equipment in service for which it was not designed frequently causes trouble; practical discussion of control equipment breakdown and methods of prevention.

Currents

HAZARDS. Note sur la tension non dangereuse des courants électriques (Safe Voltages of Electric Currents), Feraud. *Société Francaise des Electriciens—Bul.*, vol. 1, no. 3, Mar. 1931, pp. 288-301 and (discussion) 302-305. Qualitative definition of safe voltages; influence of characteristics of source on hazards, influence of outside circumstances at source on hazards; dangerous current; quantitative analysis of safe voltages; conclusions.

Dielectrics

X-RAY ANALYSIS. X-Ray Studies of Motions of Molecules in Dielectrics Under Electric Stress, R. D. Bennett. *Franklin Inst.—Jl.*, vol. 211, no. 4, Apr. 1931, pp. 481-487, 7 figs. Experiments at Ryerson Physical Laboratory lead to conclusion that molecular group state of liquid is accentuated as liquid solidifies leading to definite crystalline structure, which can be strongly oriented by electric field; it is concluded that X-ray methods may prove useful tool in investigation of molecular motions in dielectrics.

Electricity

Electricity—What It Is and How It Acts—L, A. W. Kramer. *Power Plant Eng.*, vol. 35, no. 9, May 1, 1931, pp. 514-516. Electron and proton as factors in explaining radiation from sun and stars.

Electric Drive

BLOOMING MILLS. 5000 Hp. D-C. Motor Drives New Algoma Rail and Structural Mill, A. F. Kenyon, *Elec. News*, vol. 40, no. 7, Apr. 1, 1931, pp. 54-56, 4 figs. Demands of Canadian railways for longer and heavier steel rails has necessitated complete rebuilding and electrification of the rail and structural mill of Algoma Steel Corporation, Sault Ste. Marie, Ont.; initial rolling of 26 in. x 26 in.—13,500 lb. ingots is in electrically driven 35 in. reversing blooming mill, ingots being reduced to 10 in. x 10 in. and smaller blooms, depending upon product being rolled in finishing mills.

PAPER AND PULP MILLS. New Mill Drive at Smith Paper Co. Aids Heat Balance, R. A. Packard. *Power*, vol. 73, no. 13, Mar. 31, 1931, pp. 504-506, 6 figs. Synchronous motor on turbine shaft permits unit to be governed by low-pressure steam demand; surplus or efficiency of power being taken by utility system; diagram of steam distribution at Columbia mill; diagram of main electrical connections.

PUMPS. Selecting the Motor to Suit the Pump, E. C. Dieffenbach. *Power*, vol. 73, no. 17, Apr. 28, 1931, pp. 656-659, 6 figs. Starting conditions and nature of various loads determine motor and control; to choose wisely, both motor and pump characteristics must be understood; drives for reciprocating, centrifugal, rotary and screw pumps are discussed; characteristic curves.

ROLLING MILLS. Modernizing Rolling Mills Electrically. *Iron and Steel Industry*, vol. 4, no. 7, Apr. 1931, pp. 235-238, 4 figs. Examples of modern main drives for rolling mills carried out by English Electric Co.; sheet-mill and merchant-mill drive; large motor for Brown Bayley and Co.; exciter set for mill motor; strip mills and cold-roll drives; heating of sheet-mill rolls; special tube-mill installation; frequency standardization; switchgear.

WIRE DRAWING MACHINES. Electric Equipment for Wire Drawing, T. R. Rhea. *Wire*, vol. 6, no. 5, May 1931, pp. 165-167-170 and 185, 8 figs. Various types of machines and type of motors and control which experience has determined as most suitable.

Electric Equipment

AUTOMOBILES. Modern Electric Equipment of Motor Vehicles, V. A. Karpov. *Electritchestvo*, no. 2, Feb. 1931, pp. 69-76, 10 figs. Systematic review of electric equipment of motor cars, tractors, and motorcycles; typical schemes of electric equipment for modern motor vehicles of different systems applied in U.S.S.R. and other countries; power-supply systems and electric accessories are critically described. (In Russian.)

MAINTENANCE AND REPAIR. Maintenance Methods for Electrical Equipment, E. L. Richards. *Power Plant Eng.*, vol. 35, no. 6, Mar. 15, 1931, pp. 360-362, 3 figs. Systematic maintenance schedule insures against shutdowns and anticipates repair work; importance of inspection schedule and records; maintenance record forms.

Electric Lines

HIGH TENSION DESIGN. Design of 110- and 132 Kilovolt Steel Tower Transmission Lines. *Nat. Elec. Light Assn.—Report*, no. 17, Mar. 1931, 16 pp., 3 figs. Condensed discussion of more important factors entering into design of 110- and 132-kv. steel tower transmission lines showing what items enter into transmission line specification together with some indication of typical practise with respect to each item, *i. e.*, location, electrical clearances, conductors, tower loading, transmission tower specifications; insulation; telephone lines.

PROTECTION. Protection of Rural Lines. *Elecn. (Lond.)*, vol. 106, no. 2760, Apr. 24, 1931, p. 610. Discussion by Overhead Lines Association on control and protection of rural lines; standard nomenclature is needed; oil and air break switches compared. Before Instn. Elec. Engrs.

Electric Power

RAYON PLANTS. Electrification of a Rayon Mill. *Elec. Times*, vol. 79, no. 2055, Mar. 12, 1931, pp. 473-475, 6 figs. Power generation and distribution in Sunsheen's Mills, Ballymena, Ireland, with special reference to problem of cabling and wiring; current is generated by means of two steam-driven turbine-generators, main unit of 820-kw. output, at 400 volt, 50 cycle, three-phase, neutral point being brought out, so as to provide 230 volts for lighting; second turbine set is of 100 kw.; steam is raised in three Lancashire boilers 8 ft. by 30 ft., working at 180-lb. pressure and superheated 150 deg. fahr.

Electric Towers

TESTING. Testing Full-Size Transmission Towers, N. B. Obbard. *Eng. News-Rec.*, vol. 106, no 18, Apr. 30, 1931, pp. 735-737, 4 figs. Description of plant of American Bridge

Co., in Pittsburgh, equipped to test towers up to 100 ft. in height, either on fixed grillage or on their own earth anchors; wind and conductor loads applied simultaneously at as many as seven points by pulling rig actuated by 50,000-lb. mechanical screw.

Electrodes

POTENTIALS. The Nernst Equation—A New Equation for Electrode Potentials—1, M. Meyer. *Chem. News*, vol. 142, no. 3701, Mar. 20, 1931, pp. 179-183, 2 figs. Many corrections have been applied to concentration of "active" material in effort to secure better agreement; all save "activity" coefficient fail; textbooks still make curious comments about equation; since electromotive force measurements may be made with great precision it may be of interest to examine some and also another possible equation which, however, because of its nature, seems only of academic interest.

Engineering

BUSINESS RELATIONS. Shall We Revise Our Conceptions of Engineering Functions, L. E. Jermy, *Machine Design*, vol. 3, no. 5, May 1931, pp. 23-25, 2 figs. Study of relationship and responsibilities of engineer to principal departments of industrial organization; chart illustrates relationships of chief engineer.

EDUCATION. A Suggestion for Engineering Education, L. E. Moore, *Boston Soc. Civil Engrs.—Jl.*, vol. 18, No. 4, Apr. 1931, pp. 95-102. Development of engineering education; engineering specialties; search for school to meet ideals for training; suggested course for students in engineering, natural philosophy, and sciences; author criticizes existing system for turning out men who are too often narrow technicians instead of scientifically educated gentlemen, capable of taking hold of any branches of applied science and by study specializing in them.

INFLUENCE ON CIVILIZATION. Technology and Material Progress, W. R. Whitney, *Science*, vol. 73, no. 1877, May 8, 1931, pp. 483-486. It is claimed that accumulated data of all material progress never were so great and never so uniformly appreciated; those who are interested in technical progress look at it as continuous, but do not necessarily overrate its importance; there must be parallel advance for higher values in man. Before Am. Philosophical Soc.

Engineers

RESPONSIBILITY. The Responsibility of the Engineer, R. V. Wright. *Engrs. and Eng.*, vol. 48, no. 4, Apr. 1931, pp. 73-75. Economist as well as engineer has been sticking too much to cold facts and seems to have overlooked fact that most precious factor in industry, human element, must be handled in entirely different way from materials and natural forces; now great problem of engineer is to deal with human life in industry. Before Engrs. Club.

Exciters

TURBO-GENERATORS. Turbo-Generator Exciters, W. Sharp. *Elec. Times*, vol. 79, no. 2059, Apr. 9, 1931, pp. 659-660, 6 figs. Probable lines of progress and subsequent developments in connection with manufacture of turbo-generator exciters; subject as direct bearing upon possibility and advisability of making continuous-current exciter remote from turbo-generator.

Furnaces

ANNEALING. Electric Annealing of Aluminum. *Foundry Trade Jl.*, vol. 44, no. 763, Apr. 2, 1931, p. 244, 1 fig.; see also *Metal Industry (Lond.)*, vol. 38, no. 14, Apr. 3, 1931, p. 364, 3 figs. and *Mech. World*, vol. 89, no. 2310, Apr. 10, 1931, p. 343. To facilitate precise annealing of aluminum sheets on large scale, General Electric Co., has installed large single-rack multi-car type electric annealing furnace which has effective hearth area 24 ft. long by 7 ft. 5 in. wide in works of Aluminum Corp., Dolgarrog, Carnarvonshire; furnace has electric loading of 150 kw., heating elements arranged to ensure phasal balance on 440-volt, 3-phase, 50-cycle supply.

HEAT TREATING. Bright Anneals in Artificial Atmospheres, J. C. Woodson. *Elec. Jl.*, vol. 38, no. 4, Apr. 1931, pp. 246-247, 3 figs. Possibilities of annealing in artificial atmospheres, which process is still in development stages, are not known; however, certain surface conditions can be obtained that reduce number of subsequent operations and greatly increase die life and reduce machine work; various types of electric furnaces are illustrated.

STEEL MAKING. Montreal Plant Produces Electric Furnace Steel in Large Quantities. *Can. Machy.*, vol. 42, no. 5, Mar. 5, 1931, pp. 27-30, 5 figs.; see also *Iron and Steel Canada*, vol. 14, no. 2, Feb. 1931, pp. 30-32, 3 figs. Canadian Tube and Steel Products, Ltd., Montreal, has become independent for their steel ingot and rod requirements through installation of electric steel-melting furnaces; installation consists of two Volta furnaces of Heroult type; electrode arrangements; furnace tilting; oxidation and reduction; low voltage use; ingot stripping.

Generators

HIGH-VOLTAGE. New Surge Generator. *Elec. Jl.*, vol. 28, no. 4, Apr. 1931, p. 245, 2 figs. Trend toward increased insulation for given operating voltage has necessitated higher and higher testing voltages in recent years; improved equipment to provide 1,000-kv. 60-cycle, and 3,000-kv. surge voltages has therefore been installed at Trafford High Voltage Laboratory; new equipment will greatly facilitate development work on insulation, as it is now necessary to determine performance on lightning voltages of all high-voltage apparatus.

High-Voltage Surge Testing, F. R. Benedict. *Elec. Jl.*, vol. 28, no. 4, Apr. 1931, pp. 216-218, 10 figs. In performing high-voltage surge tests on apparatus it is essential that shape of surge generator wave be under accurate control; steepness of wave front, magnitude of crest, and duration of tail can all be varied by use of proper circuit constants; elimination of oscillations at crest of wave is of considerable importance from standpoint of voltage measurement.

Grounding

CABLES. Der Doppelerdschlusstrom in Drehstromkabeln und seine Einwirkung auf benachbarte Fernmeldekabel (Double Ground Current in Three-Phase Cables and its Effect on Nearby Telephone Cables), W. Wild. *Wissenschaftliche Veroeffentlichungen aus dem Siemens-Konzern*, vol. 10, 1931, pp. 51-77, 25 figs. Origin is studied on basis of equivalent circuit diagrams; it is concluded that, with consideration of loads already present before occurrence of double ground, networks fed from one end are to be considered as networks fed from either end; protection is deduced from impedance diagrams; study of harmonics. Bibliography.

Heating

BUILDINGS. Building Heating. *Elec. Rev.*, vol. 108, no. 2786, Apr. 17, 1931, pp. 689-690, 3 figs. Advantages of load are such as to justify low rates; notes on electrode boiler and thermal storage; tabular and panel heating; electricity and heating load.

Hydroelectric

PIPE LINES. Design of Pipe lines for Hydroelectric Plants, J. S. Carpenter. *Power Plant Eng.*, vol. 35, no. 7, Apr. 1, 1931, pp. 418-419. To secure most economical design of pipe line for given condition, diameter and thickness are figured by modification of Enger's formula.

POWER PLANTS. The Economics of Power Plant Design, H. G. Acres. *Elec. News*, vol. 40, no. 7, Apr. 1, 1931, pp. 36-38 and 47, 8 figs. Fixed charges and operating expenses should be considered as definite factors in design of all plants; this is well illustrated in design and construction of recently completed development for municipality of Edmundston, New Brunswick.

Hydroelectric Units Operated as Condensers, H. A. Von Eiff. *Power*, vol. 73, no. 17, Apr. 28, 1931, pp. 666-669, 5 figs. Operating hydroelectric units as synchronous condensers under certain load conditions offers possibilities of large economies in plant operation; units in Holtwood plant of Pennsylvania Water and Power Company operated as condensers; method of solving problems encountered in operation and saving attained from condenser operation; curves of water saving by condenser operation on 25-60 cycle system; power for condenser operation.

Automatic Operator for 60,000-Hp. Station, A. C. Clogher and E. N. Peterson. *Elec. World*, vol. 97, no. 16, Apr. 18, 1931, pp. 716-722, 7 figs. Control of system frequency, division of load between units and change of one unit from generator to condenser operation are automatically and very successfully performed at Morony hydroelectric development of Montana Power Co.; station is located on Missouri River about 18 mi. below Great Falls, Mont.; two 22,500-kw. units are installed.

Rock Island—A Power Development on the Columbia River, T. B. Parker. *Elec. Light and Power*, vol. 9, no. 5, May 1931, pp. 22-27, 7 figs. Hydroelectric development is being built for Washington Electric Co., subsidiary of Puget Sound Power & Light Co., principal distributor of power in western Washington; it will be first large low-head development in Northwest; designed for ultimate capacity of 150,000 kw. under normal head of 48 ft.; initial installation will be 60,000 kw.

Industrial Progress

RUSSIA. Russia, H. L. Cooper. *Engrs. and Eng.*, vol. 48, no. 4, Apr. 1931, pp. 76-86. How communism has come about, as told by consulting engineer for 800,000-hp. hydroelectric and navigation project under construction on Dnieper River in Russia; statistics of Dniebrostroi hydroelectric projects; organization and how work is being done; statistics about Dnieprostroi hydroelectric development; notes on Five-Year Program.

Insulation

The Physics of Insulating Materials—V, A. M. Thomas. *World Power*, vol. 15, no. 88, Apr. 1931, pp. 307-310. Failure of dielectrics under stress; discharges in solids; mechanical deformation of dielectric due to electric force. Bibliography.

LINES, HIGH TENSION. Performance of Wood Insulation in Transmission Lines, F. E. Andrews. *Elec. World*, vol. 97, no. 17, Apr. 25, 1931, pp. 780-782, 5 figs. No interruptions due to lightning flashover as indicated by line trip-outs and no cases of 60 cycle power arcs following lightning flashover are recorded for 1930 on 90 mi. of all-wood constructed 33-kv. lines on Public Service Co. of Northern Illinois' system; this performance compares with respective figures of 42 and 30 for same items per 100 miles of line on 1025 mi. of previous construction.

MACHINERY. What is Good Insulation on Electrical Machines, J. L. Rylander. *Power*, vol. 73, no. 11, Mar. 17, 1931, pp. 438-441, 5 figs. Insulation failure is common evil of all electrical equipment; outline of methods for determining failure when cleaning and drying of electrical machine; effect of moisture and temperature; insulation values of different types of electrical machines as determined by tests.

MICA. The Permittivity and Power Factor of Micas, C. Dannatt and S. E. Goodall. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 412, Apr. 1931, pp. 490-496, 5 figs. Attention is drawn to electrode difficulty in testing mica, and tests are described which show order of contact effect which may be obtained with ordinary mercury electrodes; means are described by which electrode contact effect with mica may be entirely eliminated, and test results are given proving this point; test results on power factor and permittivity of ruby, green, and amber micas are given.

Light and Lighting

HIGHWAY. Illuminated Highways are Safer, D. M. Diggs. *Nat. Safety News*, vol. 23, no. 5, May 1931, pp. 19-20, 58 and 60, 5 figs. Examples showing that modern highway lighting lessens dangers that lurk in darkness and aids night travel.

INDUSTRIAL. Maintenance of the Illumination System of an Industrial Plant, R. C. Smith. *Mech. Eng.*, vol. 53, no. 5, May 1931, pp. 371-375, 6 figs. Details and results of efficiency and depreciation study of shop-lighting fixtures undertaken to obtain definite data upon which to base recommendations regarding lamp renewals and cleaning schedules. Before "Three-M" (Management, Materials, Maintenance) Congress, Cleveland, Ohio, previously indexed from advance paper.

MEASUREMENT. The Photoelectric Cell and Electric Clock as a Means of Recording the Daily Hours of Bright Sunshine, W. A. Thomson. *Can. Jl. Research*, vol. 4, no. 3, Mar. 1931, pp. 299-303, 2 figs. Method is presented whereby accurate record of daily hours of bright sunshine is made by electric clock, controlled, through relay, by intensity of light incident upon cathodes of suitably exposed photoelectric cell.

Lightning

MEASUREMENTS. Instruments for Lightning Measurements, C. M. Foust. *Gen. Elec. Rev.*, vol. 34, no. 4, Apr. 1931, pp. 235-246, 35 figs. Latest developments and applications of surge-voltage recorders; cathode-ray oscillographs; lightning-stroke recorders; surge indicators; lightning-severity meter.

Lightning Arrester

The Theory of Surge Absorbers, J. M. Thomson. *Elec. News* vol. 40, no. 9, May 1, 1931, pp. 41-42, 2 figs. Device that is essentially air core inductance connected in series with line, close to apparatus to be protected, and is operated by wave-front steepness of surge.

Magnetic Testing

IRON AND STEEL. Non-Destructive Tests by the Magnetic Dust Method, A. V. deForest. *Iron Age*, vol. 127, no. 20, May 14, 1931, pp. 1594-1595, 2 figs. Methods using magnetized iron filings for detecting cracks in ground surfaces, fatigue cracks in forgings and defects in seamless tubing; reference to work by W. E. Hoke and T. R. Watts. Before Am. Soc. Steel Treating and Am. Welding Soc.

Motor-Generators

Automatic Emergency Generating Sets, D. A. Bower. *Power Engr.*, vol. 26, no. 300, Mar. 1931, pp. 86-89 and 109, 5 figs. Sources of emergency supplies; development of emergency generating sets; principle of operation; general arrangement of emergency flywheel generating set; emergency set performing mechanical work; general layout of flywheel generating set arranged normally to perform mechanical work.

Motors

FRACTIONAL HORSEPOWER. The Woods High-Torque Fractional Horse-Power Motor, *Engineering*, vol. 131, no 3408, May 8, 1931, p. 604, 3 figs. This type of motor has disadvantage of requiring commutator, which introduces complication that may easily lead to breakdown; moreover, to short-circuit rotor windings when motor has run up to speed, it is necessary to employ either brush-lifting device or segmental brush; to overcome disadvantages M. W. Woods, London, have designed line of machines in outputs ranging from 1/8 to 1/4 hp. at speeds of from 2800 to 700 r. p. m.

STANDARDIZATION. Adaptable Electric Motors, E. G. Ross, *Elec. Rev.*, vol. 108, no. 2786, Apr. 17, 1931, pp. 664-665, 1 fig. Analysis of "special" requirements of mechanical firms shows that they can be so classified as to render perfectly feasible issuance of British Standard Specification covering exterior shapes of motors of from 1-hp. to 250-hp. rating, while simultaneously making clear that any radical production alterations are not involved.

Networks

DESIGN. Network Promises Marked Economies, D. K. Blake. *Elec. World*, vol. 97, no. 11, Mar. 14, 1931, pp. 492-495, 10 figs. Network principle promises to reduce light and power system cost and to improve service standards if it is applied to several voltage levels used in industry, simplifies system layout and engineering, makes possible manufacture of standard apparatus of single rating on production scale and reduces system investment per unit of capacity and improves service standards at minimum cost.

An A-C. System of Distribution, J. P. Heslop. *Elec. Rev.*, vol. 108, no. 2783, Mar. 27, 1931, p. 544, 2 figs. System described is claimed to possess flexibility and economy of a-c. with reliability of d-c. operation; oil circuit breakers are installed in power station only, adjacent substations being supplied from different feeders.

Designing 115-230 Volt Distribution for Modern Residential Districts, G. L. Lillie. *Elec. News*, vol. 40, no. 9, May 1, 1931, pp. 37-40 and 50, 10 figs. Fundamentals of economical service outlined; transformers should be spaced 400-600 ft. apart; secondary conductors vary from no. 0 to no. 0000.

INTERCONNECTED. Transmission and Interconnection, P. M. Downing. *Elec. Light and Power*, vol. 9, no. 5, May 1931, pp. 20-21. California's experience in diversity, load factor, rural electrification and percentage of homes wired is direct criterion of country-wide results to be expected from extension of transmission lines and their interconnection.

Phase Advancers

The Theory and Performance of Phase Advancers, J. J. Rudra and M. Walker. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 412, Apr. 1931, pp. 445-469 and (discussion) 469-486, also author's closure 486-489, 52 figs. Advancers are divided into "expedor" advancers in which voltage is proportional to secondary current, and "susceptor" advancers in which it is proportional to secondary voltage; effect of these are considered when connected to ideal motor having circle diagram of infinite radius and sets out simple relations between angle of advancer and kva. required to do what is desired.

Photoelectric Cells

Progress in Photoelectric Cells, A. J. McMaster. *Radio Industries*, vol. 5, no. 12, Apr. 1931, pp. 597-598 and 612-613, 3 figs. Types of light sensitive cells; theory of photoelectric action; cell manufacture; application; operating requirements.

Potentiometers

An Improved Feussner Type Potentiometer, M. Eppley and W. R. Gray. *Rev. Sci. Instruments*, vol. 2, no. 4, Apr. 1931, pp. 242-249, 7 figs. There are two improvements in design that can be made, one to both earlier and later forms as currently imported into United States, other to later self-checking type only; they are elimination of six contact resistances affecting measuring circuit, and addition of another standard cell dial, making it possible to adjust standard cell circuit to five places instead of to only four.

Power Factor

Checking Reverse Relay Connections, C. F. Dalziel. *Elec. West*, vol. 66, no. 4, Apr. 1, 1931, pp. 180-181, 2 figs. Most expedient method of over-all check is to connect voltmeter and ammeter in circuit with wattmeter, and from readings taken as outlined, sufficient data are obtained in order to permit power factor and "system" present to be computed; wattmeter readings obtained using voltage from potential terminals of relay. (Concluded.)

Controlling Power Factor Automatically, A. Smith. *Power*, vol. 73, no. 16, Apr. 21, 1931, pp. 632-634, 5 figs. By proper selection of motors in large industrial plant it is possible, by automatically controlling field current of large synchronous motor, to maintain plant power factor at unity; favorable power rate is obtained because of high power factor and other operating conditions; charts of power factor, incoming plant kilowatts and voltage recorded by graphic instruments; operating results.

IMPROVEMENT. Synchronous Motors Will Solve the Power Factor Problem. *Ry. Elec. Engr.*, vol. 22, no. 4, Apr. 1931, pp. 100-101 and 114, 1 fig. Modern machines combined with simplified control equipment have resulted in many successful applications that were once considered impracticable.

MEASUREMENT. Simple Power-Factor Measurement, O. Wiemer. *Elec. West*, vol. 66, no. 4, Apr. 1, 1931, pp. 186-187, 2 figs. If only instrument available is a-c. ammeter of suitable range, it is still possible and often very convenient to make power factor test; this can be done by three-ammeter method; method does not necessarily require use of three separate ammeters as name would seem to imply; equally satisfactory results can usually be obtained with only one ammeter if few simple precautions are taken.

Power Supply

RURAL. Rural Electrification Progresses in Illinois, R. Boonstra. *Elec. World*, vol. 97, no. 15, Apr. 11, 1931, pp. 693-694. Progress in rural electrification made by Public Service Co. of Northern Ill. during 1930 indicates that much can be done even in a bad business year in extending lines to farm customers and in promoting use of energy by those customers.

Radio

AMPLIFIERS. A New Method of Testing for Distortion in Audio-Frequency Amplifiers, H. J. Reich. *Instn. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 401-415, 12 figs. Periodic voltage wave consisting of series of straight lines is distorted into series of curves when it passes through amplifier which gives nonuniform amplification; as such distortion can very readily be detected visually with oscillograph, it affords means of testing for uniformity of amplification; mathematical analysis shows that "saw-tooth" voltage wave is distorted into series of exponential curves in passing through resistance-capacity-coupled amplifier.

ANTENNAS. Radio Antennas, E. F. Martin. *Radio Eng.*, vol. 11, no. 4, Apr. 1931, pp. 39-41, 7 figs. Theory of antenna arrangements; their properties of transmission and reception.

BEACONS. A Radio Beacon and Receiving System for Blind Landing of Aircraft, D. Diamond and F. W. Dunmore. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 4, Apr. 1931, pp. 585-626, 29 figs., partly on supp. plate. Receiving system for use at airports to permit blind landing of aircraft under conditions of no visibility; system comprises three elements to indicate to pilot position of aircraft as it approaches and reaches instant of landing; same medium-frequency receiving set required for obtaining radiotelephone and radio range beacon service on airways is utilized for receiving runway localizing and marker beacon signals.

COILS—RESISTANCE. The High-Frequency Resistance of Coils, A. L. Green. *Experimental Wireless*, vol. 8, no. 91, Apr. 1931, pp. 183-191, 6 figs. It is shown that there are methods of measuring high-frequency resistance of coils which do not require use of thermo-junction and calibrated resistances; these methods depend on condition for oscillation in triode assembly, and simplest of them uses dynatron oscillator.

OSCILLATORS. Calculation of Electric and Magnetic Field Strength of any Oscillating Straight Conductors, R. Bechmann. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 461-466, 1 fig. Theoretical mathematical analysis from results obtained by use of method which depends on formation of Hertzian vectors.

RECORDERS. An Automatic Recorder of Signals from A Rotating Beacon Transmitter, R. L. Smith-Rose and H. A. Thomas. *Sci. Instruments—Jl.*, vol. 8, no. 3, Mar. 1931, pp. 81-88, 5 figs. Automatic apparatus which has been developed for recording of wireless bearings from rotating beacon transmitter of type now in operation at Orfordness, Suffolk; output telephone signal current from standard type of valve receiver is supplied to tuned audio-frequency amplifier followed by rectifier; output current from this rectifier operates relay and pen which traces line record upon sheet of paper placed on rotating drum.

TRANSFORMERS. The Resistance Capacity Coupled Transformer, F. Aughtie. *Experimental Wireless*, vol. 8, no. 91, Apr. 1931, pp. 177-182, 7 figs. Use of choke in anode circuit and transformer primary being fed through suitable coupling condenser has long been known and used; authors favor circuit of where choke is replaced by resistance, by this substitution, besides removal of potential source of distortion, in shape of additional iron core, smaller self capacity of resistance as compared with choke, renders possible improvement in performance of stage at high frequencies.

ULTRA-SHORT WAVE. Ultra Short-Wave Radio-Telephony. *Elec. Rev.*, vol. 108, no. 2785, Apr. 10, 1931, pp. 622-623, 4 figs. Dover-Calais demonstration of radio-telephony on 18-cm. wave-length which marks striking advance in technique of electro-optical directive operation.

A New Wireless System. *Engineer*, vol. 151, no. 3926, Apr. 10, 1931, p. 413, 5 figs. Demonstration was given on Mar. 31 by International Telephone and Telegraph laboratories of "Le Matériel Téléphonique," of Paris; by means of new wireless telephone and telegraph equipment, largely developed by French engineers, in Paris laboratories, two-way telephone communication was established between Dover and Calais, on wavelength as low as 18 cm.

Railroad

ELECTRIFICATION. Suggestions as to the Future of Railroad Electrification, F. H. Shepard. *New York Railroad Club—Off. Proc.*, vol. 41, no. 5, Mar. 1931, pp. 9561-9653. Future outlook of electrification in America; reasons for extension.

Heavy Electric Traction Progress in America, C. Kerr, Jr. *Tramway and Ry. World*, vol. 69, no. 19, Apr. 16, 1931, pp. 187-190, 8 figs. Brief review of two outstanding installations; design, construction and operating developments in locomotives motor development; control improvements; Deion trolley breakers, frequency changer sets.

POWER FACTOR IMPROVEMENT. Importance of Power Factor Improvement, W. K. Fuzzelle. *Ry. Elec. Engr.*, vol. 22, no. 3, Mar. 1931, pp. 75-76 and 83. Transmission and distribution systems loaded with wattless current cannot function economically; remedy lies in wider application of synchronous motor.

Rating

ELECTRIC MACHINERY. New Ratings for Electrical Machinery. *Elec. World*, vol. 97, no. 15, Apr. 11, 1931, p. 679. Recommendations of International Electrotechnical Commission proposed for international use at recent seventh plenary meeting, held in Stockholm *i. e.*, internationally specified limits of temperature rise for rotating machines and transformers; temperature rises reduced for use in tropical climates; tolerances allowable in electrical machine ratings.

Reactive Power

ELECTRIC METERING. Reactive Kva. Metering—VII, E. C. Goodale. *Elec. West*, vol. 66, no. 4, Apr. 1, 1931, pp. 181-183, 3 figs. Effect of unbalanced load upon accuracy of registration of three-phase three-wire reactive meters.

Rectifiers

CONTROL. On the Contact Conduction and Rectification, G. Hara. *Ryojun College of Eng.—Memoirs*, vol. 3, no. 4-A, 1931, pp. 223-224, 19 figs. Author intends to deduce approximate formula for contact conduction

lying cold emission theory to contact, and to make clear mechanism of contact and tification. Bibliography. (In English.)

esistance

GROUND. The Measurement of Earth sistances, G. F. Tagg. *Elec. Times*, vol. 79, 2061, Apr. 23, 1931, pp. 741-743, 6 figs. gulations as to earthing; systematic tests; mentary methods of measurements; three nt method; bridge methods; fall of poten- method; Siemens-Halske earth tester; ggar earth tester; specific resistance of earth.

MOISTURE FILMS. Electrical Resistance Moisture Films on Glazed Surfaces, G. G. ail, R. J. Brooksbank, and W. M. Thornton. *tn. Elec. Engrs.—Jl.*, vol. 69, no. 411, Mar. 1, pp. 427-436, 15 figs. Research is described wo parts, first dealing with relations between face resistivity, humidity and temperature, l second with influence of gas pressure, both ing for their object discovery of laws of film mation under controlled conditions.

ark Gaps

ELECTRODES. The Development of an ctron Emitting Alloy, O. S. Duffendack, A. Wolfe and D. W. Randolph. *Electro- m. Soc.—Advance Paper*, no. 59-17, Apr. 27, 1, pp. 157-173, 11 figs. After many experi- nts, nickel alloy containing barium has been eloped which is homogeneous in composition l readily reproducible; spark gaps having ctrodes made of this alloy have very constant rking voltages; alloy has marked electron itting properties that make it valuable for in various electrical devices; its uses in eral ways are being developed.

ability

ALTERNATORS. Power System Stability, A. Hamilton, Jr. *Eng. Jl.*, vol. 14, no. 4, r. 1931, pp. 227-242, 31 figs. Methods of dicting power limits under steady or transient ditions have been outlined in various publi- ions and are available to system designers; per presents in more elementary fashion tain concepts upon which these methods are ed; factors which affect power limits are cussed and their interrelation illustrated; thods of increasing power limits are discussed.

arting

ELECTRIC MACHINERY. The Starting otors, J. Sachs. *A EG Progress*, vol. 7, no. 4, r. 1931, pp. 85-91, 11 figs. Starting processes aining with asynchronous and synchronous chines when employing starting motors; s indicated by few examples that with large chine units, but particularly phase advancers, ployment of starting motors exercises very orable effects upon starting conditions, such smaller apparent power consumption, smaller ial current surges and higher power factor.

bstations

RECTIFIER. La sous-station automatique clairage de Cannes (Automatic Substation). *ie Civil*, vol. 98, no. 5, Jan. 31, 1931, pp. -118, 4 figs.; see also brief translated abstract *Power Engr.*, vol. 26, no. 301, Apr. 1931, p. . Equipment of Bergerie, Cannes substation verts 10,000-volt three-phase, 25-cycle sup- into continuous current at 250 volts for ting and general service; in order to avoid se or other nuisance, mercury-vapor rectifier adopted as converting equipment.

vitchboards

SPECIFICATIONS. Nema Panelboard and tribution Board Standards. *Nat. Elec. rs. Assn.—Pub.*, no. 31-4, Jan. 1931, 31 pp., figs. Standards on design and construction panelboards; switchboards; cabinets and ipment boxes; commercial standard practise.

SUPERVISORY CONTROL. Supervisory trol Equipment. *Elec. Rev.*, vol. 108, no. 4, Apr. 3, 1931, p. 611, 2 figs. Supervisory ipment for remote control of three sub- ions, two of rotary type for traction purposes one of transformer type, of Auckland Elec- Power Board in New Zealand, has recently n completed by Automatic Telephone Manu- uring Co., Ltd., in collaboration with tropolitan-Vickers Electrical Co., Ltd.; de- ptive details of apparatus is given.

vitchgear

LOSSES. Eddy Current Losses in Heavy rent Switchgear—II, J. E. Shaw. *World wer*, vol. 15, no. 88, Apr. 1931, pp. 295-299, gs. Iron loss in mold steel, switch tops; erimental results of measurements discussed in detail; experimental investigation of iron loss in plate, due to single conductor carrying current definite distance from it. (Concluded.)

Synchronizers

CLOCKS, ELECTRIC. Ein funkenfreier Synchronisier-Apparat fuer Nach- und Voreilen (Spark Free Synchronizer for Lagging and Advanced Currents), H. Bock. *Zeit. fuer Instrumentenkunde*, vol. 51, no. 4, Apr. 1931, pp. 197-204, 5 figs. Synchronizing equipment, for electric pendulum clocks, is detailed.

Television

QUALITY. Quality of Television Images, D. K. Gannett. *Bell Laboratories Rec.*, vol. 9, no. 8, Apr. 1931, pp. 358-362, 5 figs. Since each cycle represents two picture elements, number of picture elements which could be received is 10,000 in second, or 625 in 1/16 of second; no matter how good television apparatus, therefore, no better quality picture could be obtained than containing 625 elements, or about 22 by 28 elements.

Transformers

Recent Progress in Large Transformers, R. M. Charley. *Instn. Elec. Engrs.—Preprint*, for mtg., Apr. 16, 1931, 15 pp., 16 figs. General description of progress made in recent years and examples illustrating present stage of art.

Ultra Violet

WINDOW GLASS. Glasses for Use with Invisible (Ultra-Violet and Infra-Red) Rays, S. English. *Jl. of Good Lighting*, vol. 24, Feb. 1931, pp. 27-31 and (discussion) 32-35, 13 figs.; see also *Nature (Lond.)*, vol. 127, no. 3200, Feb. 28, 1931, pp. 310-312, 2 figs. Nature of invisible rays; spectrum; characteristics of certain radiations; ultra-violet transparencies of two glasses of similar composition; relative transparency of various glasses; ultra-violet transmission of various window glasses; effect of artificial aging on two types of ultra-violet glass; spectra of various ultra violet light sources; Wood's glass and fluorescence; light transmission and heat absorption of various glasses.

Vacuum Tubes

GLOW. A New Television Lamp, G. Gruskin. *Radio Industries*, vol. 5, no. 12, Apr. 1931, pp. 593 and 611-612, 1 fig. Development of radically improved type of point-source light by W. G. Taylor of Taylor Vacuum Products Co., does away with many limitations formerly ascribed to mechanical scanning; author has not yet been granted authority to release details of tube's construction or operating principles.

INDUSTRIAL APPLICATIONS. Vacuum Tubes In Industry, P. G. Weiller. *Radio Eng.*, vol. 11, no. 4, Apr. 1931, pp. 31-34, 4 figs. Important progress is being made in design and manufacture of mercury vapor rectifier tubes and tubes useful for automatic control of operating electric circuits; many opportunities await cooperative studies between tube engineers and engineers engaged in mechanical industries.

Voltage Regulators

The Application of the Induction Voltage Regulator, W. E. M. Ayres. *Instn. Elec. Engrs.—Preprint*, for mtg., Apr. 16, 1931, 11 pp., 21 figs. General application of induction regulators to feeder systems and distribution networks; problem of fully automatic control is dealt with and various methods of parallel working are discussed; point of application of regulator in system is considered from its practical and economic aspects.

Voltmeters

HARMONICS. Ein Oberwellen-Voltmeter (Harmonic Wave Voltmeter), R. Oetker. *Zeit. fuer Technische Physik*, vol. 12, no. 4, 1931, pp. 205-210, 10 figs. Description of simple and exact indicating instrument for effective value of harmonics of distorted voltage curve.

IONIC. The Ionic Wind Voltmeter and Thermo-Electrostatic Relay, W. M. Thornton and W. G. Thompson. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 412, Apr. 1931, pp. 533-544, 18 figs. Electric wind observed in neighborhood of highly charged point in air is caused by repulsion of ions which collide with uncharged molecules of air, thus giving to them velocity and, in effect, causing wind from point; instrument based on this action, termed "ionic wind voltmeter," was designed to indicate voltage of any system above few thousand volts by making earthed electrode part of hot-wire bridge.

Wave Filters

Extensions to the Theory and Design of Electric Wave-Filters, O. J. Zobel. *Bell System Tech. Jl.*, vol. 10, no. 2, Apr. 1931, pp. 285-341, 18 figs. Derivation and composition of wave-filter structures; designs of networks which simulate impedances of wave-filters, and of loaded lines; four Appendices contain new reactance and wave-filter frequency theorems, particular fixed transducer designs and certain equivalents.

Welding

ARC. Arc Welding in 1931, J. F. Lincoln. *West. Machy. World*, vol. 22, no. 2, Feb. 1931, pp. 65-66, 3 figs. Every year since war use of arc welding has gained greater momentum in practically every industry; regardless of economic outlook for 1931, it is safe to say that this process will be applied more widely and more frequently than in any preceding year; development of electrodes during past year for welding of various steel alloys will bring about much wider application of arc welding and in turn permit wider use of these alloy metals, particularly that of stainless steel and other corrosion-resisting metals.

Arc Welding Everdue, T. E. Jerabek. *Boiler Maker*, vol. 31, no. 3, Mar. 1931, pp. 68-69, 5 figs. Property of copper-silicon-manganese alloy, known as everdur; advantageous welding characteristics; procedure of metallic arc-welding process.

ARC-TESTING. Inspection Safeguards Quality, R. Kraus. *Welding Engr.*, vol. 16, no. 4, Apr. 1931, pp. 27-31, 14 figs. Inspection and testing methods of Westinghouse Co., with incorrect and correct sketches of welding procedure and layout of weld; testing of welders and dimensions of test specimens. Before Am. Soc. Testing Matls.

BOILER MANUFACTURE. New Technique in Welding is Result of Years of Scientific Research, K. B. Lydiard. *Pit and Quarry*, vol. 22, no. 2, Apr. 22, 1931, pp. 62-64, 11 figs. Results of investigations and laboratory experiments by research engineers of Babcock and Wilson; based on which technique was evolved which produces welds equal to or better than welded plate itself in tensile strength, shock resistance, ductility, and in ability to withstand repeated stresses; results obtained when this technique is used to weld carbon steel of firebox quality.

GAS PIPE LINES. Development and Results of Arc Welding of Gas Pipe Lines, H. C. Price. *Oil and Gas Jl.*, vol. 29, no. 48, Apr. 16, 1931, pp. 148 and 150. Review of development of electric welding of pipe lines, since 1928, with particular reference to long distance natural gas lines; operating practise; results; tests; advantages. Before Am. Gas Assn.

MACHINERY MANUFACTURE. Welded Construction Applied to Special Machinery, D. V. Waters. *Product Eng.*, vol. 2, no. 4, Apr. 1931, pp. 167-170, 6 figs. As result of development of acetylene and arc welding technique in recent years, welded steel construction in places where such construction was formerly deemed impracticable, is now used to good advantage; savings of both money and time in construction have resulted from use of welded steel; adaption of welding to special machine construction.

SHIPBUILDING. Electric Welding in the Construction of Sea-going Vessels, G. Wahl. *Shipbldg. and Mar. Engine Bldr.*, vol. 38, no. 251, Apr. 1931, pp. 324-326, 12 figs. Experimental ship constructed by Deutsche Werke in order to find new methods of electric welding applicable to shipbuilding and for training of welders; results of tests and conclusion. Before Instn. Engrs. and Shipbldrs. in Scotland.

VENTILATION DUCTS. Welded Fabrication of Ductwork, W. Spraragen. *Heat. and Vent.*, vol. 28, no. 3, Mar. 1931, pp 54-57, 9 figs. Preparation of material in repetitive production work; types of joints; expansion and contraction; stack welding.

Welding Machines

SPOT. The Dyer Bench Spot Welder. *Engineering*, vol. 131, no. 3401, Mar. 20, 1931, p. 408, 1 fig. Bench-type welder manufactured by Dyer Welding Machine Corp., Independence, Mo.; arrangement it is claimed, enables various parts to be joined together at place where they are assembled, thus saving time; welder is capable of making 1,000 welds per hr. on no. 16 gage sheet, variation in heat necessary for different metals being obtained through medium of three-position switch, which is fixed to housing containing transformer.

Industrial Notes

The Holophane Company, Inc., 342 Madison Avenue, New York, announces the appointment of A. D. Cameron as manager. Mr. Cameron was formerly active in the lighting field as manager of the lighting and supply division, central station department, General Electric Company, Schenectady, N. Y. Later he was vice-president of the Hall Electric Heating Company, of Philadelphia.

Ohio Brass Insulators Conform to New NEMA Standards.—To meet the new standards for switch and bus insulators decided upon at the May meeting of the National Electrical Manufacturers Association, the Ohio Brass Company, Mansfield, Ohio, announces a new line ranging in voltage ratings from 7.5 kv. to 69 kv. These new insulators, which simplify the construction, maintenance and repair problems of the user and make it much easier to coordinate line and station insulation, are now available for immediate shipment.

Miniature Relays.—A new line of miniature relays to be known as "Mid-Gett" is being made in eight contact arrangements by Struthers Dunn, Inc., 129 N. Juniper Street, Philadelphia. They are on standard bases and measure 1⅞ in. by 2¾ in., and follow in detail the design of regular type Dunco relays, having the three-legged stool principle of construction, form-wound, moisture-proof coils, renewable contacts, accessible terminals, with moulded bases. They operate on from 6 to 120 volts alternating current, or 24 volts direct current, depending upon the coil used.

New Vulcanized Fibre Insulation.—A new insulating material known as Dilecto K-4 is being produced by the Continental-Diamond Fibre Company, Newark, Del., manufacturers of Bakelite materials and vulcanized fibre. In addition to unusually high electrical insulating properties, Dilecto K-4 has high thermal insulating efficiency, is odorless and does not attract odors. It is finding a wide use as breaker strips on electric refrigerator cabinets. The material, which is highly resistant to alkali solutions and to water and moisture, will be made in sheets, rods and tubes, and can be machined readily.

Telegraph Code for the Electrical Industry.—A standard telegraph code for the electrical industry, sponsored by NEMA and other electrical associations, has been compiled under expert supervision for the use of the entire electrical field, not only for economy in communication, but to provide means for more frequent, accurate and comprehensive exchange of information of immediate necessity. According to the announcement it is the first instance of an entire industry uniting on a general code, and its cheap distribution is dependent upon the response to the pre-publication offer as detailed in the prospectus which is available upon application to the National Electrical Manufacturers Association, 420 Lexington Avenue, New York.

Trade Literature

Motors.—Bulletin 209, 32 pp. Describes type "D" heavy duty direct-current motors. Reliance Electric & Engineering Company, 1042 Ivanhoe Road, Cleveland.

Bridge-Stop Control.—Bulletin, 4 pp. Describes the new EC & M dynamic braking, bridge-stop control. This braking equipment is used on electrically operated overhead traveling cranes. The Electric Controller & Mfg. Company, 2700 East 79th Street, Cleveland.

Magnetic Clutches.—Bulletin, 24 pp., "Keeping Pace With Machine Design." Describes the construction, application and operation of C-H magnetic clutches, including a full description of the newly developed C-H duplex clutch. Cutler-Hammer, Inc., 12th & St. Paul Avenue, Milwaukee.

Circuit Breakers.—Bulletin 484, 4 pp. Describes type DR line oil circuit breakers, manual and electrical remote control, up to 2,000 amperes, 15,000 volts; 3,000 amperes, 7,500 volts; 60 cycle ratings, automatic or non-automatic. These breakers are designed for indoor service where space is an important factor. Condit Electrical Manufacturing Corporation, Boston.

Mercury Arc Rectifiers.—Bulletin 1907, 16 pp. Describes steel tank mercury arc rectifiers for converting alternating to direct current over wide ranges of both voltage and current. The most general use of this equipment is in supplying power for electric traction systems, although it has certain industrial applications. Westinghouse Electric & Mfg. Company, East Pittsburgh.

Switchboards.—Bulletin 293, 18 pp. Describes Bull Dog "Saf to Switch-Boards" type DF-30. These are of standardized sectional construction, totally steel enclosed, consisting of one or as many panels as desired, allowing changes or extensions, as requirements may demand. The scheme of standardization not only includes switches, but has been developed to cover air and oil circuit breakers, meters, etc. Bull Dog Electric Products Company, 7610 Jos. Campau Avenue, Detroit.

Hardness Testing Machine.—Bulletin, 24 pp. Describes the Firth Hardometer. This device extends the reliable Brinell method of hardness testing for use with thin materials, case hardened or nitrided surfaces, small parts, or any condition where a small indentation is necessary or desirable. The Firth hardometer differs from other instruments intended for the same purpose in that the diameter or diagonal of the impression is measured instead of the depth. Tinius Olsen Testing Machine Company, 500 No. 12th Street, Philadelphia.

Power Filter Unit.—Bulletin, 4 pp. Describes a new power filter unit which converts alternating current into pure, non-pulsating, humless direct current for use on telephones, sound-on-film, public address systems, inter-communication systems, clock and signal systems, magnetic chuck operation, elevator control and many other applications. The use of batteries in connection with the power filter unit is unnecessary, except where a standby source of direct current is required. Square D Company, 6060 Rivard Street, Detroit.

Potentiometer Pyrometers.—Catalog 1101, 48 pp. Describes a new line of potentiometer pyrometers having a broad application to industrial needs involving the measurement and control of temperatures, especially in the higher ranges. The introduction outlines the nature and field of the potentiometer principle as applied to pyrometers. The various types of these instruments include indicating, recording, controlling, multiple recording and multiple controlling. The Brown Instrument Company, Windrim & Wayne Streets, Philadelphia.

Lightning Arresters.—Bulletin 20365-A, 4 pp. Describes autovalve lightning arresters for the protection of railroad signal apparatus. Bulletin 20149-G, 4 pp., describes type SV autovalve lightning arresters for station use either indoors or outdoors, 1,000 to 220,000 volts. Bulletin 20013-K, 8 pp., describes type LV autovalve lightning arresters for the protection of distribution transformers. Bulletin 1737-F, 24 pp., is a comprehensive, illustrated publication describing autovalve arresters in general and the correct method of installation. Detailed engineering discussions, supplemented by drawings and diagrams, clarify many arrester problems. Westinghouse Electric & Mfg. Company, East Pittsburgh.

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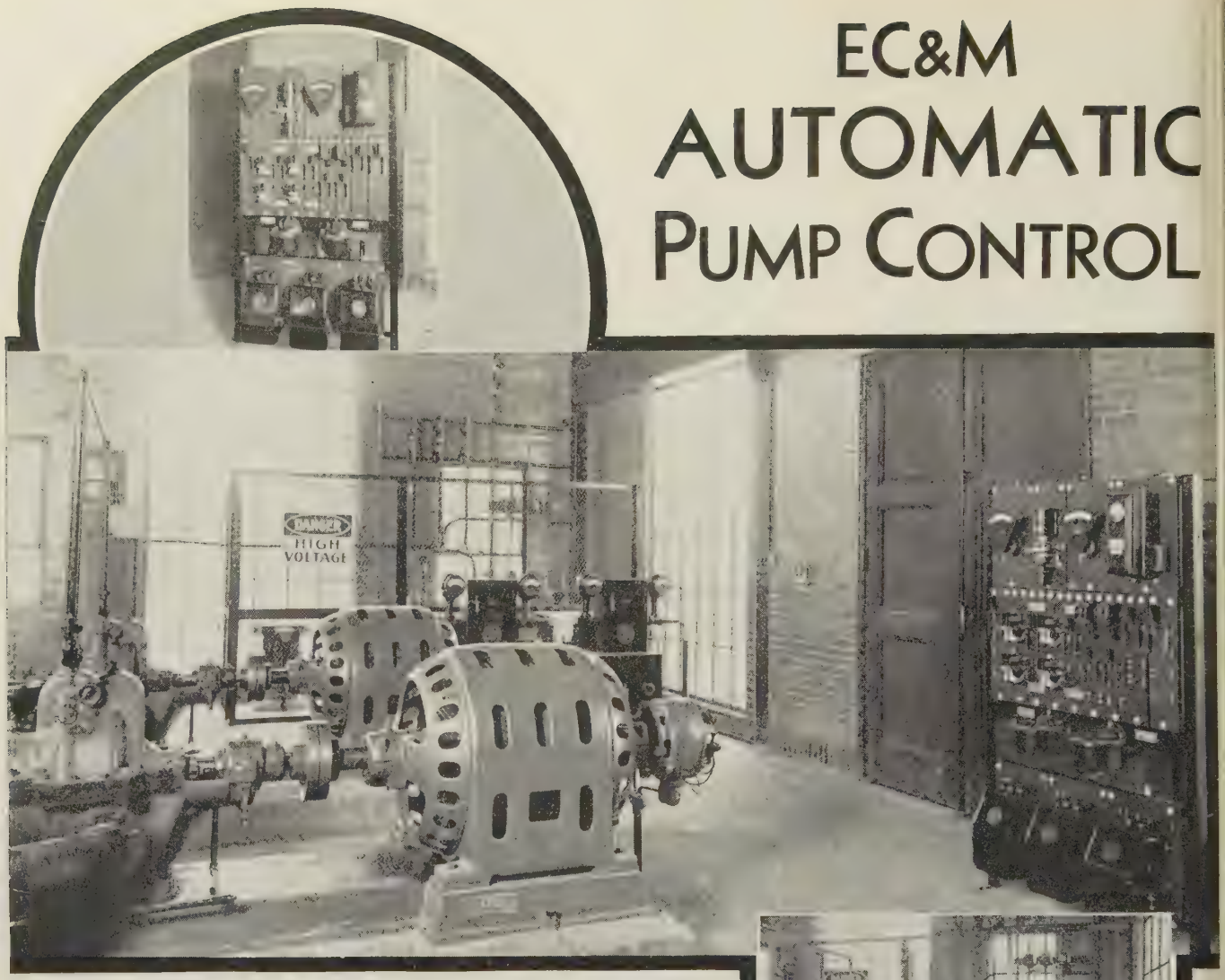

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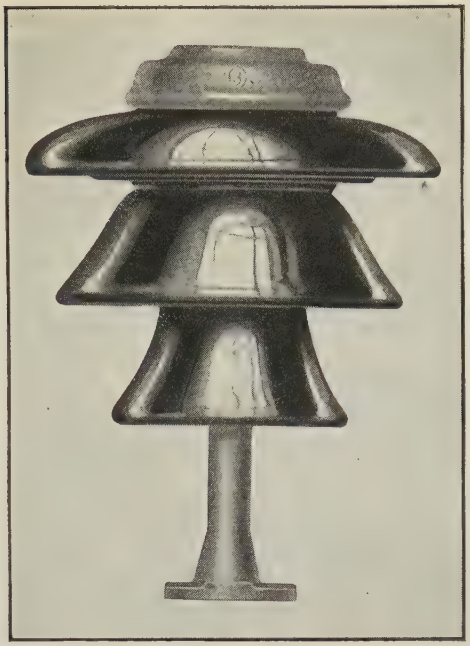

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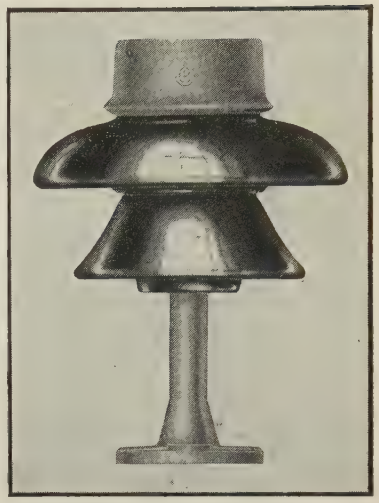
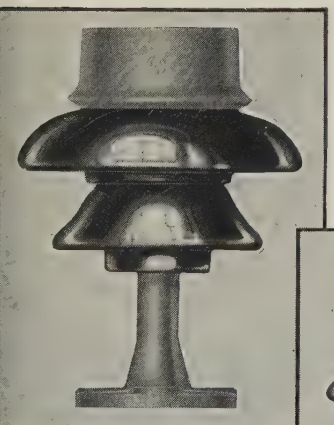


No. 31302. *General rating 23,000 volts, overall height 12 inches. Diameter of porcelain 9 inches. Will meet N.E.M.A. standard flashover requirements of 70 kv. wet and 95 kv. dry. 3-in. bolt circle, 4 bolt holes tapped ½-in. 13 U.S.S.*



No. 31301 *(Left) 15,000 volts. Ht. 10-in. Porcelain Dia. 7½-in. Meets N.E.M.A. standard flashover requirements of 50 kv. wet and 75 kv. dry.*

No. 31300 *(Right) General rating 7,500 volts, overall height 7½ inches. Diameter of porcelain 6¾ inches. Will meet N.E.M.A. standard flashover requirements of 35 kv. wet and 55 kv. dry. 3-in. bolt circle, 4 bolt holes tapped ½-in. 13 U.S.S.*

RECOGNIZING the need for standardization in switch and bus insulators, the National Electrical Manufacturers Association, a year ago, appointed a special committee to investigate this problem. At the Hot Springs meeting, May 18th to 21st the findings and recommendations of this committee were submitted, and adopted as standard by the association.

The many advantages to be gained by these new N.E.M.A. standards are recognized. Substation design, maintenance and repairs are simplified. In coordinating line and station insulation, the established values of switch and bus insulators make possible a proper balance with line insulation.

So, to make these N.E.M.A. standards immediately effective, there is announced a new line of O-B switch and bus insulators for voltages from 7,500 to 69,000. This new line embodies all of the advantages inherent in earlier designs; such as the treated sanded surface; the proper ratio of metal to porcelain; design and contour of the parts; jig assembly which insures accuracy in overall height, vertical alignment of the bolt holes and paralleling of the upper and lower faces.

Four of the new group of O-B switch and bus insulators, which conform to the new N.E.M.A. standards are illustrated. Your O-B representative has complete information on these as well as insulators for higher voltages on which standardization is not completed.

OHIO BRASS COMPANY, MANSFIELD, OHIO
Canadian Ohio Brass Company Limited, Niagara Falls, Canada

435H

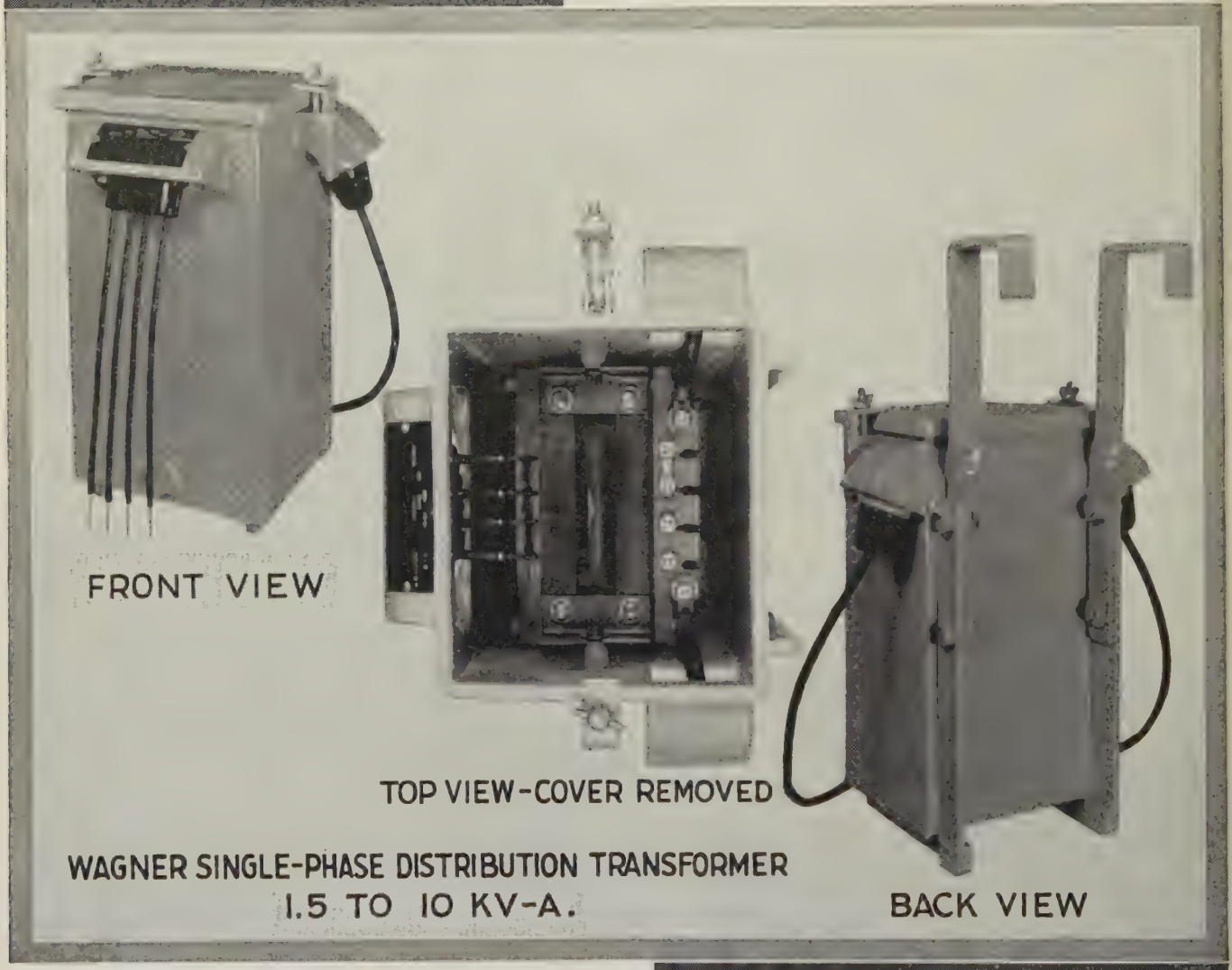
Ohio Brass Co.

NEW YORK PHILADELPHIA PITTSBURGH BOSTON CHICAGO CLEVELAND ST. LOUIS ATLANTA DALLAS LOS ANGELES SAN FRANCISCO SEATTLE

PORCELAIN INSULATORS
LINE MATERIALS
RAIL BONDS
CAR EQUIPMENT
MINING MATERIALS
VALVES

User-designed distribution transformers

Wagner's new improved line of distribution transformers embody all the desirable features of design and construction suggested by power company engineers during the past few years. Thus these transformers are "user-designed," built in accordance with the wishes of Wagner customers. » » » To mention a few of the outstanding features: tanks and covers are made of copper-bearing steel; top of case shell is flanged for greater rigidity and to provide liberal seat for cork cover gasket; skids and hanger supports of bar iron welded to bottom and back, increase rigidity; skids protect bottom against injury and paint removal; hangers bolted to supports, increase tank rigidity;



WAGNER SINGLE-PHASE DISTRIBUTION TRANSFORMER
1.5 TO 10 KV-A.

pressed steel lifting hooks are welded to side walls; cover is crowned; cover clamps (of eye-bolts, wing nuts and clips) permit removal of cover without detachment of any nut or bolt; large, strong drain plug, easily removed, will not rust, sealed with copper-asbestos gasket; removable type bushings set at pronounced angle to give ample clearance between leads and tank, protected from injury by steel hoods projecting beyond them. » » » Study the accompanying illustrations; order these transformers and examine them. You'll find they meet your idea of what distribution transformers should be—for they were designed in accordance with the recommendations of power company engineers.

Wagner
Electric Corporation
6400 Plymouth Avenue, Saint Louis, U. S. A.

MOTORS TRANSFORMERS FANS
LOCKHEED HYDRAULIC BRAKES

T331-6XA

....and more than fifty percent

f all the insulators n the 220 kv trans- nission lines in this ountry today were esigned and man- factured by Locke

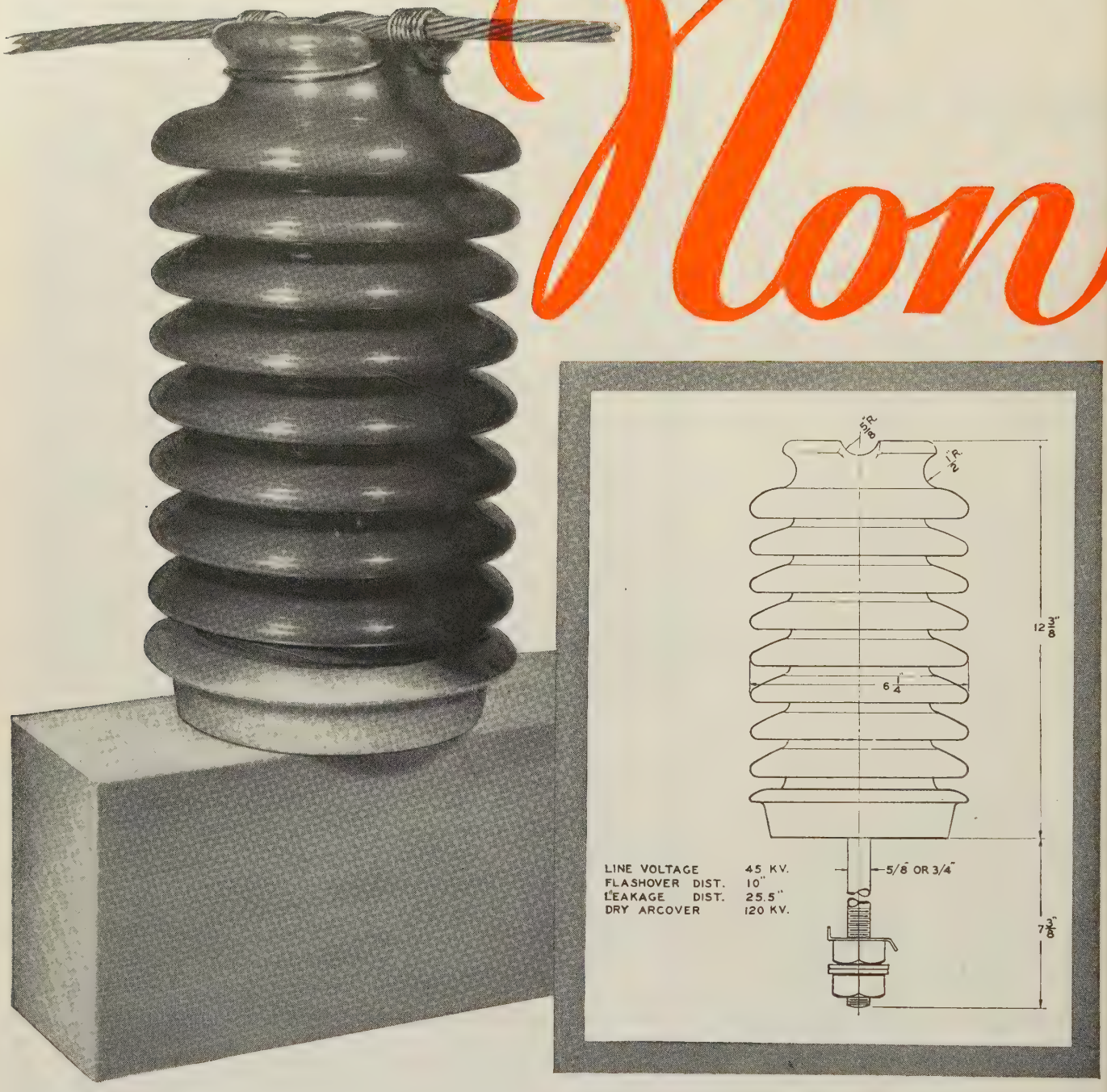
ne engineers who put in the first 220 kv line the country knew that particular attention ust be paid to the insulators. The high me- anical and electrical loads these would be lled upon to carry made flawless insulators sential. They selected Locke Suspension sulators as have the majority of engineers on nilar developments since.

course, there is a reason for this. The de- gn of Locke Suspension Insulators is the out- me of many years of practical experience th in the use of insulators and in their anufacture. The ruggedness necessary un- r modern conditions, the maximum strength d the long life have all been assured by the sign. Locke Suspension Insulators of the me design as the ones being produced today have been in active service for over sixteen years without any record of failure. The ar- duous research, the constant improvement in processes, and the exact factory control have added further improvements. Today in the Locke Suspension Insulator you get not only greater resistance to breakage and higher me- chanical strengths but you also get an insulator which by every known gauge is practically proof against deterioration.

Regardless of voltage, your own lines are of prime importance to you. If you have not al- ready done so why not follow the example of the engineers who have been responsible for the construction and operation of the coun- try's 220 kv systems and specify Locke Sus- pension Insulators?"

LOCKE PORCELAIN INSULATORS

OCKE INSULATOR CORPORATION • • • • BALTIMORE, MARYLAND



Non

Radio Engineer of Large Power Company Reports:

"We were able to impress approximately 60,000 volts across the insulator before corona appeared on the conductor and tie wire. At this point interference started in but no corona was audible on the insulator up to 75,000 volts to ground. We can state definitely from our tests today that interference does not appear 60 KV to ground and it is probable that the critical point is higher.

"From a radio interference standpoint this insulator seems to be approximately 75% better than any other type which we have tested . . . I believe that serious consideration should be given for standard construction. All the rest of the ordinary pin type insulators have been treated with a view to raising the critical voltage point but this type seems to have gotten at the root of the whole trouble by greatly reducing the capacity of the unit and by making solid contact between the pin assembly and the porcelain."

Compare these figures with the 7 and 10 KV at which radio interference starts on most conventional pin insulators.

Static...

LAPP *Line-Post* Insulator No. 8052

THIS new Lapp *Line-Post* Insulator solves the problem of radio interference due to insulators. And without resorting to superficial attachments, coatings or treatments which tend towards deterioration—or even sometimes aggravate the trouble. The improvement lies in the design.

Terminals placed far apart minimize electrostatic capacity. With low capacitance, the charging current flux through air, particularly around the line terminal, is reduced below the critical point.

This wide spacing is made possible by eliminating the pin, which in the Lapp *Line-Post* Insulator is replaced by a cemented metal base of sufficient area to diffuse the accompanying flux at low intensity. How effective this new insulator has proved in test is indicated in the letter on the preceding page.

Mechanical Superiority—Short thick flanges reenforce and protect a porcelain body of exceptional solidity. We believe these units impervious to stones or lead rifle bullets. Even a steel-jacketed bullet might only rip off a portion of one petticoat, but do little damage to the insulator's electrical characteristics. The wide open shells of a standard insulator, especially vulnerable to direct hits from below, are eliminated in this design—the bottom protected by the projecting splash lip of the metal base.

Stability Under Arcover—Compared to standard units the *Line-Post* presents little or no area at the top where conventional pin-type insulators are exposed to cracking under localized heat. The bottom is free from broad flanges into which an arc might rise with destructive burning. Even if the relays should not open, the Lapp *Line-Post* Insulator should outlast the conductor. The heavy metal splash lip at base provides a smooth rounded terminal for electrostatic requirements plus ample metal for resisting burning under power arcover. This insulator will remain crack-free in normal service and puncture-proof under any circumstances.

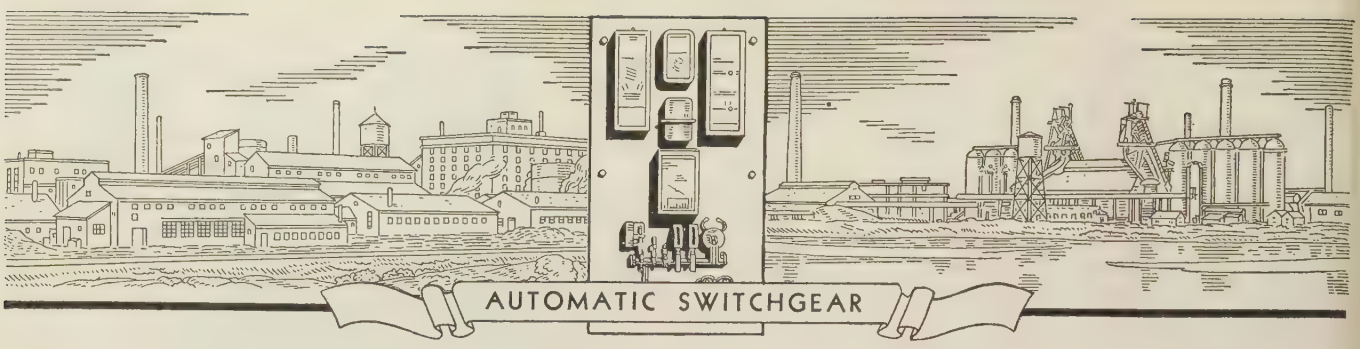
Excess Strength—The better pins used today are rated at 3000# with a 10° deflection. Tests show that the *Line-Post* stands well in excess of 3000# with practically no deflection.

Stresses Obviated—Under cantilever load any insulator mounted on a metal pin has within the pin-hole severe bursting pressures. In the *Line-Post* a much more favorable loading is secured; the metal base aids the porcelain by supporting it *outside* with a low-intensity compression grip.

Combats Dirt, Contamination—Adherence to the proved Lapp Fog Type design gives the *Line-Post* excellent behavior under dirt or contaminated atmospheric conditions. Absence of partly-dry high resistance shielded leakage surfaces in series with wetted exposed external surfaces makes possible for the first time in a line insulator a completely wetted, electrically quiet, leakage path. The splash lip on the base wets the lowest corrugation underneath (as the others wet those above them) eliminating the last chance of an arc-sputter over a dry spot which would cause radio interference.

Write for sample and details

APP INSULATOR CO. INC — LAPP INSULATORS — LE ROY - N.Y. - U.S.A.



FOR INDUSTRIES THAT REQUIRE CONTINUITY OF SERVICE

A CERTAIN process in making plate glass requires a continuous 24-hour-a-day supply of power; one second's failure is serious. This fact led the Pittsburgh Plate Glass Company to install automatic switchgear in the main substation of its plant at Ford City, Pa.

To obtain a like continuity of power supply, the National Tube Company, McKeesport, Pa., has made its nine substations automatic. The machines and automatic regulating equipment are arranged to deliver rated current to the 250-volt d-c. system down to practically zero bus voltage in order to maintain power supply to vital machinery.

In small plants, automatic switchgear fits in just as well. The standby equipment at the Ann Lee Home, Colonie, N. Y., consisting of two 50-kw. gasoline-engine-driven generators, is placed in operation automatically upon failure of the normal supply.

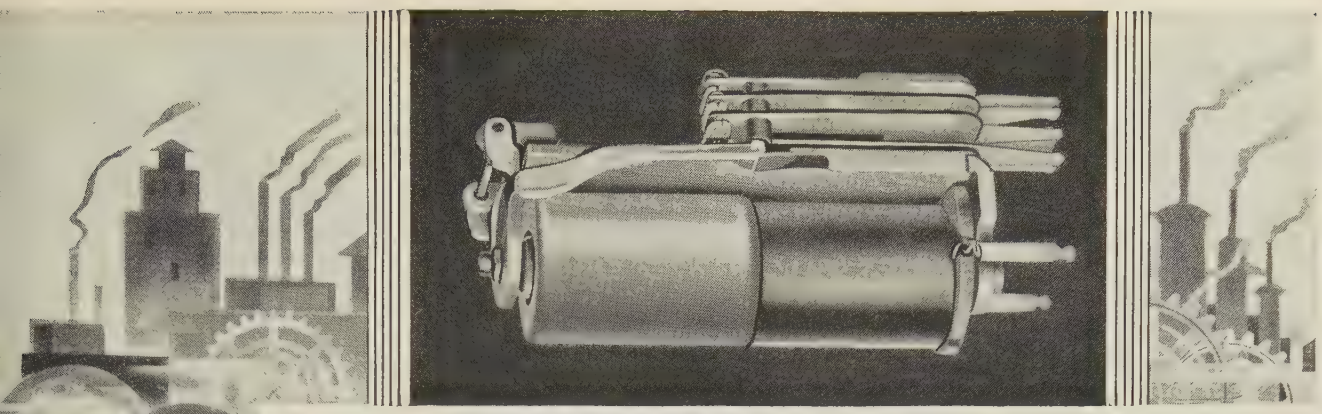
Improved service continuity is just one reason why automatic switchgear has won such wide acceptance in the industrial field. It has also bettered labor conditions, increased reliability, and reduced operating expenses. And it usually pays for itself in less than three years.

The practical experience of General Electric engineers is at the disposal of every company interested in determining whether automatic switchgear will fit in its modernization program. Refer to the switchgear specialist through the nearest G-E office.

460-52

GENERAL ELECTRIC

SALES AND ENGINEERING SERVICE IN PRINCIPAL CITIES



STROWGER RELAYS

HELP WHIRL THE WHEELS OF INDUSTRY

Get the Facts *on these* Strowger Products

esides Strowger Dial Telephone quipment—the accepted dial elephone system for private or- anizations and public systems like — Automatic Electric Inc. ffers the following line of per- ected communication systems and quipment. For information on any r all of them, use the coupon.

- Railway Communication and Signal Equipment
- Industrial Fire Alarm Systems
- Code Signal Systems (Audible and Visual)
- Supervisor's Boards for Power Networks
- Municipal Fire Alarm Systems
- Police Recall and Alarm Systems
- Theatre Telephone and Signal Systems
- Portable Telephones and Line Test Sets
- Watchmen's Supervisory Systems
- Remote-Control Time Recorders
- Relays, Remote-Control Switches and Signal Accessories

INDUSTRY'S growing use of electrical communication and control equipment is reflected in the increasing interest being shown in Strowger products by industrial engineers and executives.

Strowger relays and remote-control switches are the essential elements of Strowger Dial Telephone Equipment. In appreciation of the qualities which have led to the world-wide adoption of this equipment, manufacturers have formed the habit of consulting with the Strowger staff in all problems involving communication or remote-control over wires. It is a profitable habit, for Strowger apparatus comes to them ready made—perfected—with all experimentation completed and all doubt as to reliability and long life completely removed.

Wherever there is need for communication or remote-control over wires—in business organizations, industrial plants, railroads, public utilities, municipal departments or private organizations—Strowger products should be given first consideration. For your own ultimate profit write for illustrated literature, mentioning, if possible, your particular line of interest.

Engineered, Designed and Manufactured by

Automatic Electric Inc.

Factory and General Offices:

1031 West Van Buren Street, Chicago, U. S. A.

SALES AND SERVICE OFFICES:

Atlanta, Boston, Cincinnati, Cleveland, Detroit, Kansas City, Los Angeles, New York, Pittsburgh, St. Paul, Washington

ATTACH TO YOUR LETTERHEAD AND MAIL TO

AUTOMATIC ELECTRIC INC., 1031 W. Van Buren St., Chicago

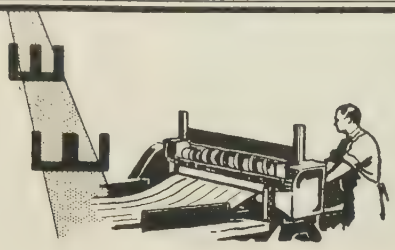
Please send us bulletins on:

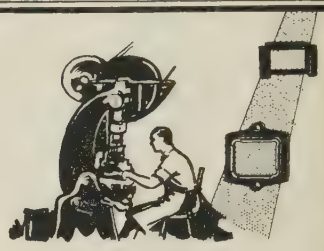
- ☐ Private Dial Telephone Systems
- ☐ Relays and Remote-Control Switches
- ☐ Fire Alarm Systems
- ☐ Railway Communication Equipment
- ☐ .....

Name .....

Position .....

From Transformer Headquarters





Here are Facilities for Exceptional Service

Any Transformer • Any Quantity • Any Delivery

Cores

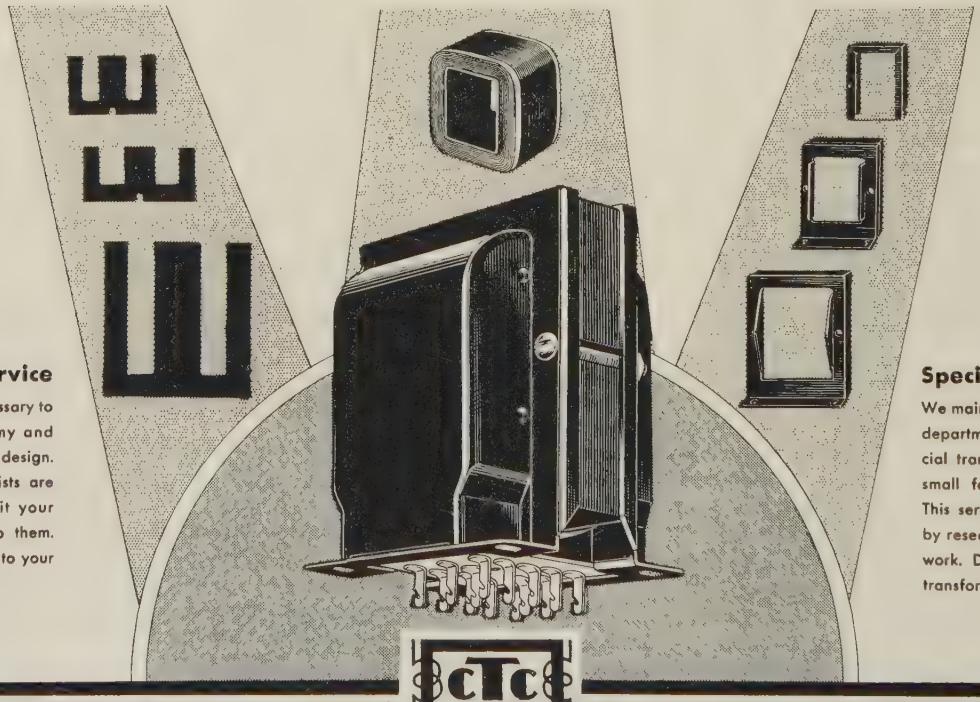
The C. T C. range of core sizes makes it easy to fill any special transformer order from our stock of standard laminations. The C. T. C. tool room makes dies for any special core. Immediate production on any transformer order is thereby assured.

Coils

Prompt service is a simple matter because the C. T. C. coil winding department is fully equipped with the latest high speed coil winding machinery. Any arrangement of taps, turns, shielding or insulation is handled without delay. Let us quote on your next order.

Mountings

Exceptional flexibility is a big feature of C. T. C. design. A wide assortment of mountings used interchangeably on C. T. C. cores provides transformers that meet special needs at standard prices. Every C. T. C. transformer part is made in our own plant for quick service.



Engineering Service

Long experience is necessary to obtain highest economy and efficiency in transformer design. Our transformer specialists are at your service. Submit your transformer problems to them. A C. T. C. design, suited to your needs, will be submitted.

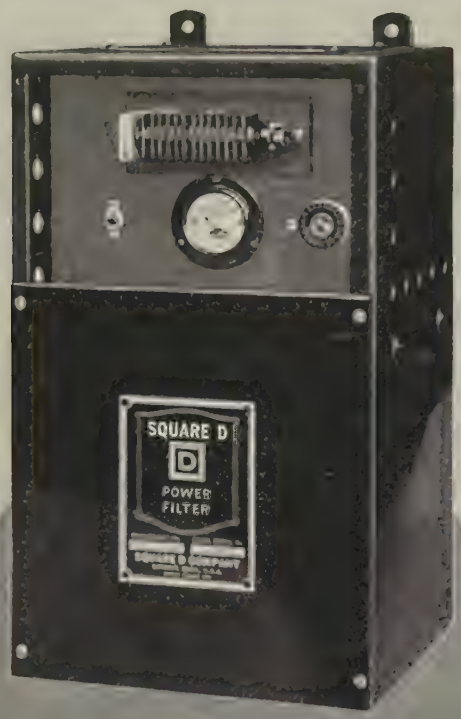
Special Transformers

We maintain a special assembly department to manufacture special transformers on orders too small for quantity production. This service is used extensively by research laboratories in their work. Do you need a special transformer? Let us quote you.

CHICAGO TRANSFORMERS

CHICAGO TRANSFORMER CORP., 2624 WASHINGTON BLVD., CHICAGO, U. S. A.

Pure non-pulsating D-C from A-C with SQUARE D power filter unit



For Magnetic Chuck Operation

For Elevator Control

For Telephone Systems

For Radio Broadcasting

The SQUARE D Power Filter Unit is not an ordinary battery charger or rectifier. It supplies a pure, non-pulsating, noiseless D. C. from an A. C. Supply without auxiliary equipment and can be used in place of batteries and motor generator sets. It has no moving parts, no hum, low impedence, close voltage regulation, instant response, and requires little or no maintenance. Write for bulletin today. Power Filter Division SQUARE D Company, 6060 Rivard Street, Detroit, Michigan.

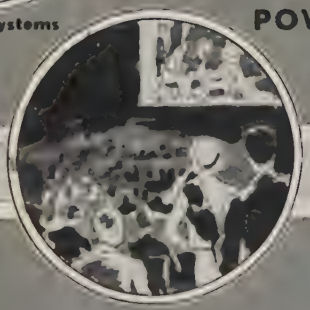
Manufacturers write for liberal marketing plan for you and your agents.

For Signaling Systems

For Intercommunication

SQUARE D

POWER SQUARE D D-C FILTER



For Sound-On-Film

For Public Address Systems

Mother *and* Father *didn't miss a word*

From their seats in the last row of the school auditorium would they be able to hear their little girl recite? The parents were pleasantly surprised when her childlike treble came across the distance clear and natural, brought by Western Electric amplifying apparatus.

Public Address Systems widen the hearing circle. They enable hundreds or many thousands, indoors and out, to hear distinctly every word of a speaker or the pianissimo tone of a musical instrument.

This equipment gives its true-to-life tonal results because it was made by an organization with fifty years' experience in *sound*—the makers of your Bell telephone. It is additional proof—along with apparatus for talking pictures, for broadcasting, for police radio, for aviation communication—of Western Electric leadership in the whole field of sound.

Western Electric

Makers of your Bell telephone and leaders in the development of sound transmission

The Western Electric Public Address System is distributed by Graybar Electric Company.

AMERICAN STEEL & WIRE COMPANY

SUBMARINE CABLES

Strength to Withstand Strain

It is not sufficient that submarine cables transmit current efficiently. In addition, their construction must embody proved principles of construction, to enable the withstanding of terrific strains and stresses. Cables of the American Steel & Wire Company, in use throughout the world, have demonstrated their superiority in every way — rendering longer service and lowering maintenance costs. Whether you need standard or special cables for submarine, overhead or underground use, you will find us ready to serve you efficiently and economically.

What happens when a ship's anchor tangles up with a cable is graphically illustrated here. The cable in question, a product of the American Steel & Wire Company—although badly twisted—continued to operate efficiently.

1831 COMMEMORATING AMERICAN STEEL & WIRE COMPANY 100 YEARS of PROGRESS IN WIRE MAKING 1931

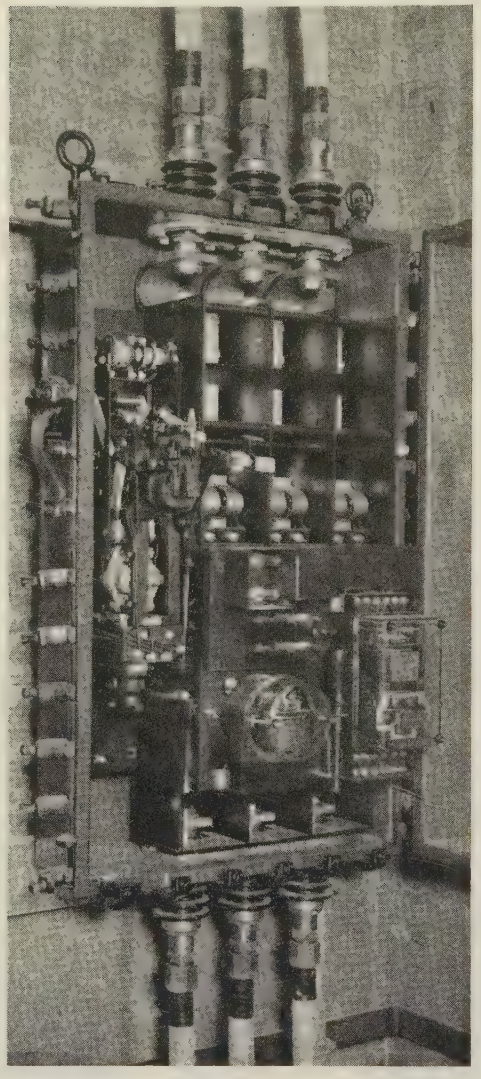
AMERICAN STEEL & WIRE COMPANY

208 South La Salle Street, Chicago — SUBSIDIARY OF UNITED STATES STEEL CORPORATION — And All Principal Cities

Pacific Coast Distributors: Columbia Steel Company, Russ Building, San Francisco — *Export Distributors:* United States Steel Products Company, New York

Note the Dossert Type F Stud Connectors connecting cables to studs at top and bottom of protector box.

NET WORK DOSSERTS



DOSSERTS used to connect 2,000,000 C.M. single conductor cables to 1½ inch copper studs on 1600 ampere, 250 volt submersible type A.C. network protector.

THE engineer on A.C. net work equipment has found Dosserts a help toward substantial construction.

On the Network Protector above, photographed on the lines of the Milwaukee Railway & Light Company, the Dosserts, connecting cable to studs, have provided not only proper electrical connection but also a fine appearance.

On all wiring work—connecting cables, stranded or solid wires, rods and tubing, there are Dosserts to aid you in substantial construction.

The Dossert book gives you full data, not only for the line, but also on wires and cables.

Write for a copy.

DOSSERT & CO., H. B. Logan, Pres., 242 W. 41st St., New York

It's a

DOSSERT

ROEBLING

THERE are men who prefer a product that is made to give lasting, efficient service, rather than to meet minimum specification requirements—a product of outstanding quality. There are men, too, who want cooperation that is friendly, thoroughly dependable and helpful.

Such men find that Roebling to an unusual degree satisfies their needs in these respects.

Roebling invites your inquiry and would welcome an opportunity to serve you. The Roebling Line of electrical wires and cables is complete and many types are available for immediate shipment at the cities listed.

Power Cables · Paper; Cambric; Rubber » Submarine Cables » Tree Wire » Parkway Cable » Service Cables » Station Cables » Rubber Covered Control Cables » Rubber Covered Wires and Cables · Braided and Leaded · Code: Intermediate; 30% » Slow-burning Wires and Cables » Weatherproof Wires and Cables » Portable Cords » And a wide variety of other wires and cables.

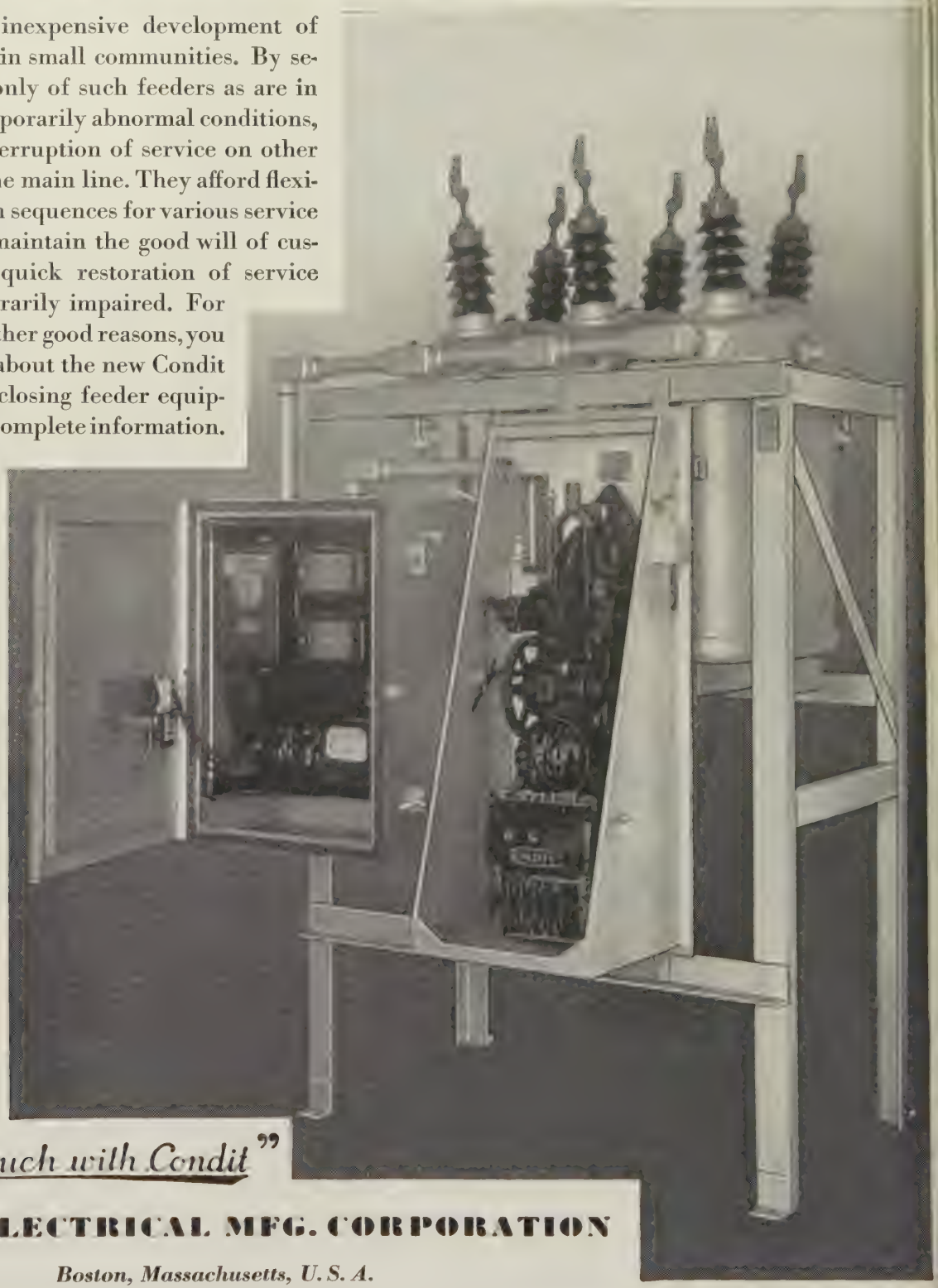
JOHN A. ROEBLING'S SONS COMPANY, TRENTON, N. J.

Atlanta Boston Chicago Cleveland Los Angeles New York
Philadelphia Portland, Ore. San Francisco Seattle Export Dept., New York, N.Y.

ELECTRICAL WIRES AND CABLES

THEY REDUCE SERVICE COST

and permit the inexpensive development of new load centers in small communities. By selective opening only of such feeders as are in trouble from temporarily abnormal conditions, they prevent interruption of service on other feeders and on the main line. They afford flexibility of operation sequences for various service conditions, and maintain the good will of customers through quick restoration of service when it is temporarily impaired. For these and many other good reasons, you should know all about the new Condit a. c. automatic reclosing feeder equipments. Write for complete information.



"Get in touch with Condit"

CONDIT ELECTRICAL MFG. CORPORATION

Boston, Massachusetts, U. S. A.

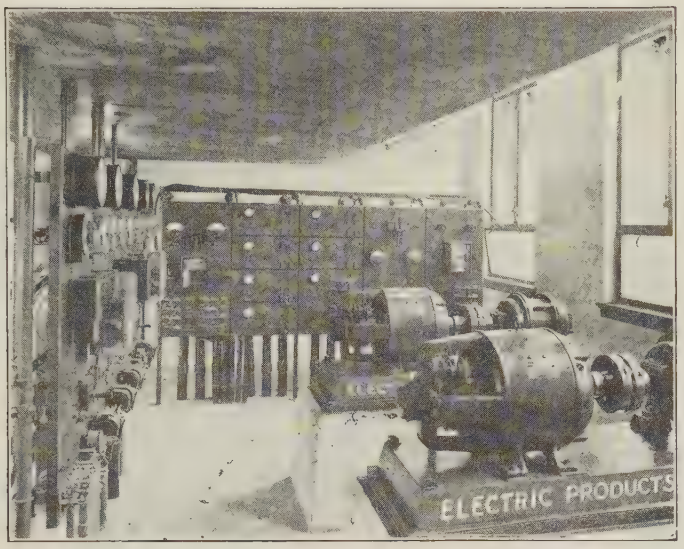
CONDIT

SHUNT WOUND BATTERY CHARGER

THE DIVERTER POLE GENERATOR

CONSTANT VOLTAGE INHERENT — RUNS AS MOTOR SAFELY

THE ELECTRIC PRODUCTS COMPANY · PATENTED · JAN. 1926 · CLEVELAND, OHIO, U.S.A.



DIVERTER POLE GENERATORS
as installed at Cleveland Union Terminal
(a $175,000,000 project)

W. S. LEE, President of the American Institute of Electrical Engineers, in his talk at the annual dinner of the Cleveland Section of the Institute, emphasized that the clever and successful engineer was one who could do the common thing in an uncommon and better way.

Charging storage batteries with DIVERTER POLE GENERATORS combines safety and economy in an uncommon way.

It is good engineering to use them.

Also Manufacturers of Low Voltage Electroplating Generators, variable speed D.C. Motors and Motor-Generators of all kinds.

The Electric Products Co.

CLEVELAND, OHIO

1725 Clarkstone Road

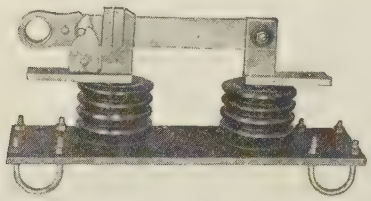
New York Office — 126 Liberty St.

R&IE

DISCONNECTING SWITCHES

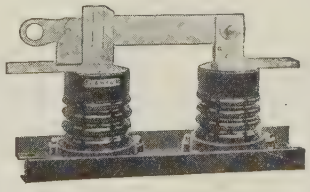
(INDOOR)

TYPE "I"



Standard duty switch with insert insulator construction. All non-ferrous parts are polished and lacquered. Contacts are carefully ground in. Latch is combination lock and blade pry.

TYPE "T"



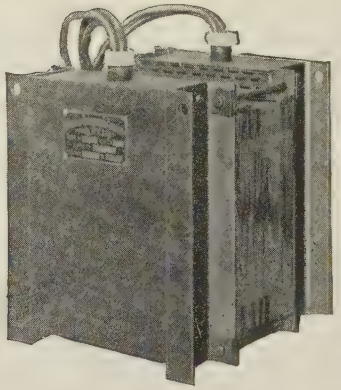
Heavy duty switches with insulator assembly of die-metal construction, polished and lacquered non-ferrous parts and combination latch and blade pry.

See Catalog Section 3310 for Information.

RAILWAY AND INDUSTRIAL ENGINEERING CO., GREENSBURG, PA.

Boston	Dallas	New York	Seattle
Birmingham	Detroit	Philadelphia	Toronto
Buffalo	Indianapolis	Pittsburgh	
Charlotte	Kansas City	St. Louis	
Chicago	Los Angeles	San Francisco	

AMER TRAN Transformers



"Built for dependable performance in all types of service."

Do you know what AmerTran offers the electrical industry?

Do you know . . . that we carry hundreds of standard transformers in stock . . . that this organization is also prepared to build special transformers of any required size to your exact specifications . . . that we have supplied leading power and industrial companies with transformers of every description for more than 29 years . . . that AmerTran transformers are considered the "Standard of Excellence" for all industrial, laboratory, and radio applications?

These are a few of the reasons why AmerTran's list of customers continues to grow larger year after year. That we are also able to hold old customers over long periods of time is explained by our service and willingness to cooperate on all problems.

The next time you need a transformer let us recommend a type to satisfy your requirements. Whether you want a small air-cooled unit of the type shown (a stock item) or a large testing transformer, we welcome the opportunity of demonstrating the quality and service associated with all AmerTran products.

Literature with complete descriptions will be mailed promptly on request.

AMERICAN TRANSFORMER COMPANY

Transformer builders for over 29 years

178 EMMET ST. NEWARK, N. J.

AMERTRAN TRANSFORMERS

Supplementing Inadequate Guying

Typical Pole Mount Construction—No. 1

The illustration features a new pole erected entirely above ground on a Williams Pole Mount because facilities were unavailable for guying in the usual manner.

Note the two full-size telephone cables on the outrigged arm in addition to upper and lower distribution circuits—all turning corner on this pole with about 30 ft. pull.

Inspection after about five years of service shows that the pole has not pulled over noticeably in the ground under this steady side pull. Thus we prove the Pole Mount will anchor the pole securely, if the pole is strong enough for the stress involved.

Along modern highways with sweeping curves, push-braces and guying across the road to stubs may be economically eliminated through the substitution of Williams Pole Mount construction.

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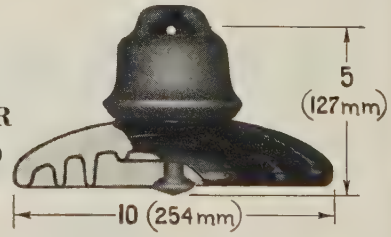

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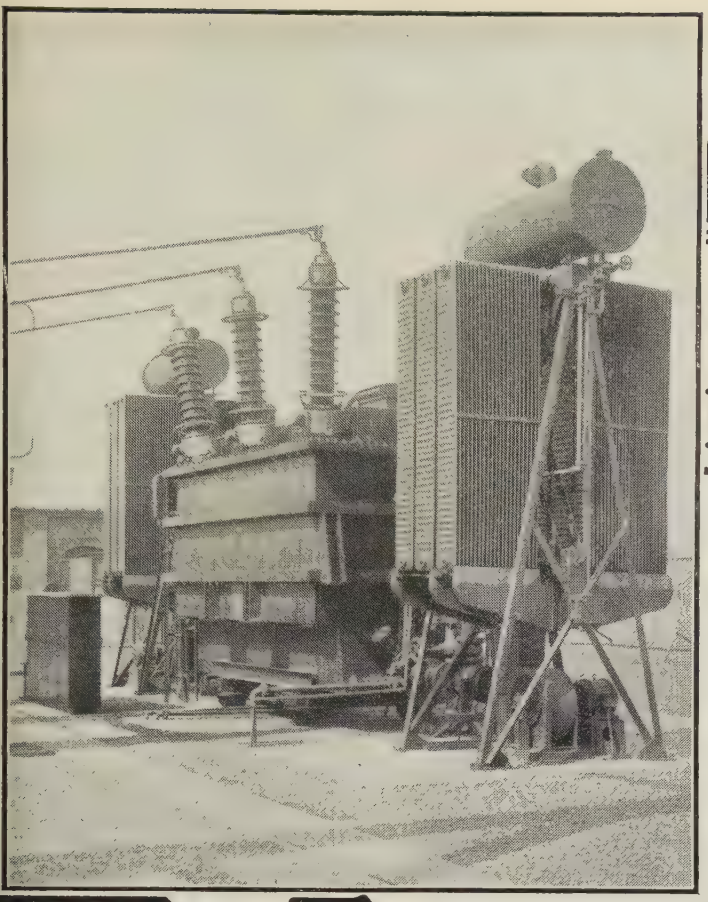

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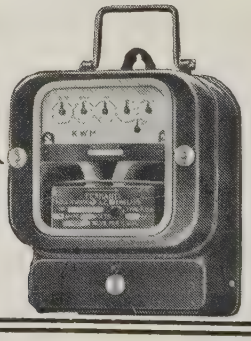

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Kuhlman Electric Co., Bay City, Mich.
Moloney Electric Co., St. Louis, Mo.
Wagner Electric Corp., St. Louis
Furnace
Allis-Chalmers Mfg. Co., Milwaukee
American Transformer Co., Newark, N. J.
Moloney Electric Co., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TRANSFORMERS—*Continued*
Metering
American Transformer Co., Newark, N. J.
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
Roller-Smith Co., New York
Sangamo Electric Company, Springfield, Ill.
Weston Elec. Inst. Corp., Newark, N. J.
Radio
American Transformer Co., Newark, N. J.
Chicago Transformer Corp., Chicago
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
Sangamo Electric Company, Springfield, Ill.
Street Lighting
Kuhlman Electric Co., Bay City, Mich.

TROLLEY LINE MATERIALS
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TURBINE GENERATORS
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TURBINES, HYDRAULIC
Allis-Chalmers Mfg. Co., Milwaukee

TURBINES, STEAM
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TURBO-GENERATORS
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

VALVES, BRASS
Gas, Water, Steam
Ohio Brass Co., Mansfield, O.

VARNISHES, INSULATING
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

WELDING MACHINES, ELECTRIC
American Transformer Co., Newark, N. J.
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

WELDING WIRES & RODS
Aluminum Co. of America, Pittsburgh
American Steel & Wire Co., Chicago
Ohio Brass Co., Mansfield, O.

WIRES AND CABLES
Aluminum and A. C. S. R.
Aluminum Co. of America, Pittsburgh
Armored Cable
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities
Asbestos Covered
American Steel & Wire Co., Chicago
General Electric Co., Schenectady
Rockbestos Products Corp., New Haven, Conn.
Asbestos, Varnished Cambric
Rockbestos Products Corp., New Haven, Conn.
Automotive
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities

WIRES AND CABLES—*Continued*
Bare Copper
American Steel & Wire Co., Chicago
General Cable Corporation, New York
Roebling's Sons Co., John A., Trenton, N. J.
Western Electric Co., All Principal Cities
Copper Clad
American Steel & Wire Co., Chicago
Western Electric Co., All Principal Cities
Copperweld
Copperweld Steel Co., Glassport, Pa.
General Cable Corporation, New York
Flexible Cord
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Flexible Cord, (Heater) Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.
Heavy Duty Cord
American Steel & Wire Co., Chicago
General Cable Corporation, New York
Okonite Company, The, Passaic, N. J.
Simplex Wire & Cable Co., Boston
Fuse
Aluminum Co. of America, Pittsburgh
American Steel & Wire Co., Chicago
General Electric Co., Schenectady
Roebling's Sons Co., John A., Trenton, N. J.
Lead Covered (Paper and Varnished Cambric Insulated)
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Okonite-Callender Cable Co., The, Inc., Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities
Leads, Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.
Magnet
Aluminum Co. of America, Pittsburgh
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Roebling's Sons Co., John A., Trenton, N. J.
Western Electric Co., All Principal Cities
Magnet, Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.
Rubber Insulated
American Steel & Wire Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities
Switchboard, Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.
Tree Wire
General Cable Corporation, New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Trolley
American Steel & Wire Co., Chicago
Copperweld Steel Co., Glassport, Pa.
General Cable Corporation, New York
Roebling's Sons Co., John A., Trenton, N. J.
Western Electric Co., All Principal Cities
Weatherproof
American Steel & Wire Co., Chicago
Copperweld Steel Co., Glassport, Pa.
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
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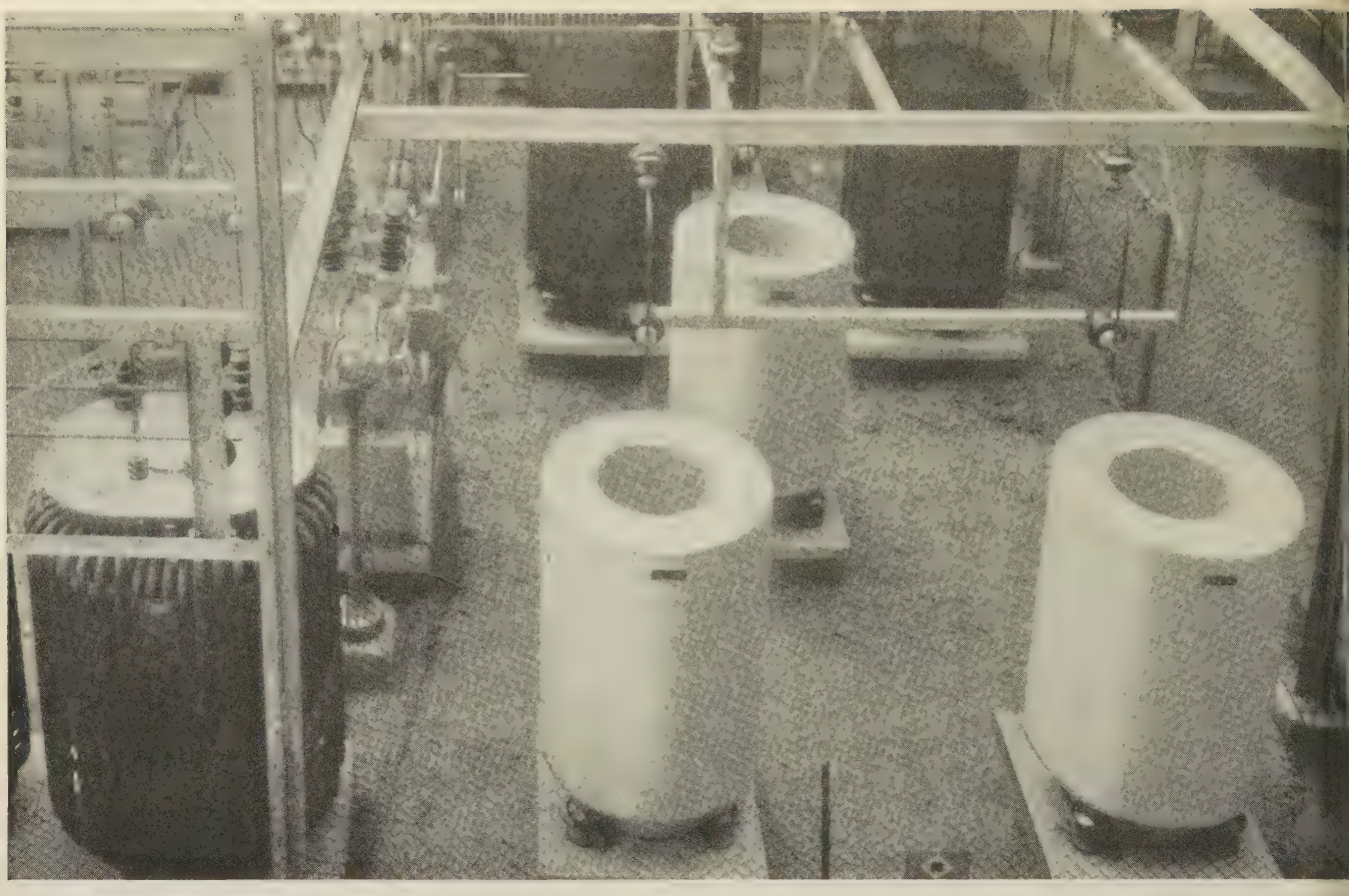

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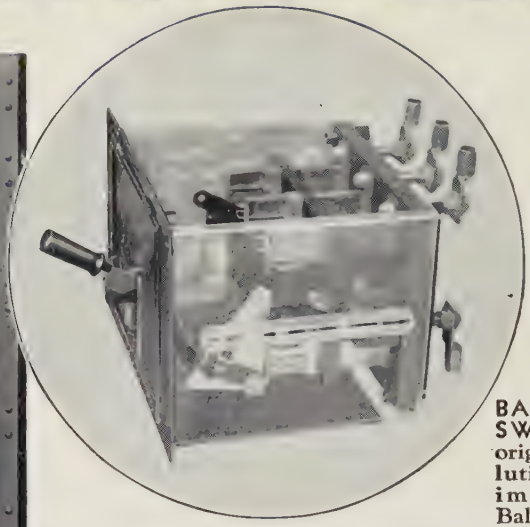

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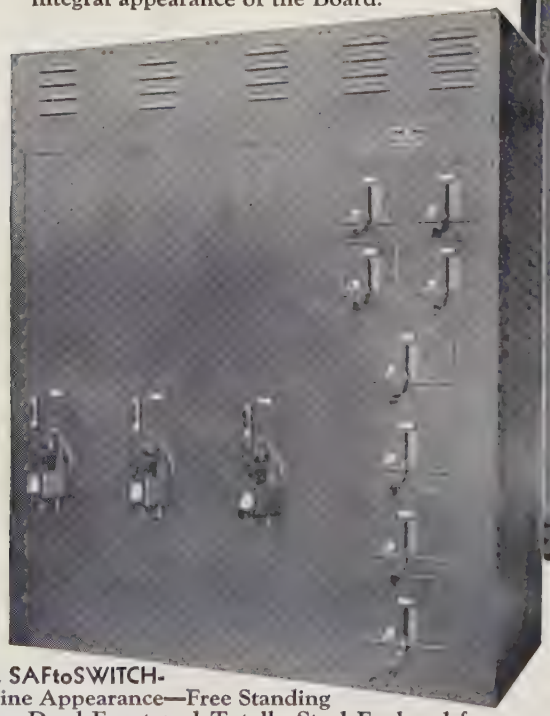

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In Two Sections

Electrical Engineering

July
1931

Section
Two

This Section Contains

the Annual Reports of the Eighteen Technical Committees of the Institute

Published by
American Institute
of Electrical Engineers, New York

Annual Technical Committee Reports To the Board of Directors

In accordance with Section 82 of the A. I. E. E. By-laws, the Technical Committees of the Institute have prepared the following reports for presentation at the Summer Convention.

In addition to a brief outline of its own activities, each committee gives a resume of the progress of the art within its field, so that collectively, these reports constitute an authoritative history of the developments in electrical engineering during the past year.

Table of Contents

Automatic Stations

ANNUAL REPORT OF THE COMMITTEE ON AUTOMATIC STATIONS*

CONSIDERABLE data on many phases of the automatic station art have been collected by subcommittees and are made part of this report, which is treated under headings as follows:

Technical Papers	Wire Designations
Standards	Research
New Subjects	Operating Data
Unfinished Business	Telemetering
Fire Protection	Bibliography

Technical Papers

The following papers are being presented under the auspices of the Committee at the Summer Convention, Asheville, N. C., 1931.

1. *A-C. Supervisory Control System.* By Othmar K. Marti.
2. *Supervisory Control for A-C. Electrified Railroads.* By C. P. West and H. C. Griffith.
3. *Automatic Combustion Control.* By C. H. Sanderson and E. B. Ricketts.
4. *Operating Experience with Automatic Stations.* By Garland Stamper and F. F. Ambuhl.
5. *Three Years' Operating Experience with Miniature Switchboard Supervisory Automatic Control.* By R. M. Stanley.

Standards

Standards No. 26, Automatic Stations, has again been reviewed by the Committee. Recommendations for revisions in the list of device function numbers and in the table of minimum protection for power apparatus have been forwarded to the Standards Committee.

New Subjects

Automatic combustion control and automatic alternating current networks have been studied this year by the Committee. A paper on Automatic Combustion Control, covering this subject extensively for the first time, is being presented at the annual convention.

Unfinished Business

Of the items listed last year, preliminary reports on Fire Protection, Load Dispatching and Wire Designations have been completed and are contained herein.

The following topics have been under consideration but no final reports have been rendered:

1. Economical Construction.
2. Noise Mitigation.
3. Automatic Alternating Current Networks.
4. General Telemetering.

Subcommittee Reports

To the Subcommittees contributing the following reports generous acknowledgment is given. It is desired to make known that the efforts so prominently reflected in these reports are appreciated in full measure.

Fire Protection

Contributed by I. E. Moultrop and D. W. Taylor.

The methods of accomplishing suitable fire protection from the points of view of safety to personnel, safety to apparatus, and continuity of service have long been the subject of discussion and investigation by the electrical engineering profession. The size and importance of electrical installations make adequate fire protection a matter of utmost importance. The increasing use of automatically operated stations brings into prominence the special problems confronted by the designers of these usually unattended installations, which may in some instances be so far removed from the nearest aid in case of fire as to make automatic fire protection a corollary of automatic operation. It is the purpose of this report to point out some of these special problems.

When the subject of fire protection is considered, it is well to make a study of the causes of fires to obtain a perspective of the various elements entering into the problem. Consideration can then be given to design, and apparatus and material specifications, which will eliminate as much as possible the trouble at the source. Studies may be made to determine if oil circuit breakers have the necessary interrupting capacity; if all load carrying apparatus has the proper thermal capacity; if relay protection can be provided to clear short circuits before damage may occur, etc. Many apparatus characteristics, such as oil circuit breaker interrupting capacities, have been proven by tests so that greater reliability may be placed in their performance than was the case a few years ago.

Means to limit the fire to the vicinity of its source and prevent involving other apparatus in an attended or unattended substation, may take any one or more of

*COMMITTEE ON AUTOMATIC STATIONS:

F. Zogbaum, Chairman,
Chester Lichtenberg, Secretary,

F. F. Ambuhl,	Joseph Hellenthal,	O. J. Rotty,
L. D. Bale,	C. A. Mayo,	Garland Stamper,
C. W. Colvin,	I. E. Moultrop,	D. W. Taylor,
A. M. Garrett,	M. E. Reagan,	L. J. Turley.

three forms, *viz.:* automatic means of fire detection and alarm; structural means of fire isolation; and means of fire fighting, either manual or automatic.

Automatic means of fire detection, as at present commercially developed, take the form of thermocouples and fusible links to convert the heat energy released by combustion into electrical energy, or of the more complicated apparatus working as a detector of the resultant smoke. Although these automatic means of fire detection have occasionally been installed in attended stations merely to alarm the operators, the recent mechanical improvement of the devices commercially obtainable for this service has resulted in considerable application of such devices in unattended stations to give alarm at some central attended installation and/or to operate fire-fighting equipment adjacent to the source of trouble. Unattended stations whose operations are reported to a central office through some means of supervisory control are particularly adapted for the installation of an alarm system between the station and the central office.

The second form of fire protection, structural means of fire isolation, is applied for the same reason and with equal effect in both attended and unattended stations. The large quantity of oil used in modern electrical apparatus makes fire isolation an important problem both indoors and outdoors. Generally, if possible, it is desirable to install large oil-filled apparatus outdoors and eliminate as much indoor oil-filled apparatus as is possible.

Indoors, apparatus of different types and different degrees of importance may be placed in different rooms, with fire doors between, either normally closed or closed by gravity upon the release of a fusible link. Some companies go so far as to install oil-immersed transformers in one room, large oil circuit breakers in a long narrow room with windows only at the ends, and oil-immersed voltage regulators in still another room; only the smaller breakers being installed in the same room with the switchboard and major bus structure. In connection with the location of windows, many stations are so arranged that any outdoor apparatus liable to catch fire, if installed adjacent to the building wall, are located at considerable distance from the nearest opening into the building. Another precaution taken as a means of indoor fire isolation comprises the use of cell doors and other trim made of treated wood or other fireproofed material. Current transformers, on which the relay protection is dependent, have been sometimes placed in separate compartments so they will not be involved in an arc from other equipment before they have actuated the tripping relays. Proper grounding of apparatus often lessens the chance of stray currents damaging other equipment during a short circuit. Elimination, as much as possible, of unprotected apparatus connected to the main bus is often desirable. Protection of apparatus, such as bus potential transformers, by means of resistance and fuses and careful isolation of bus arresters, should be considered.

Outdoors, transformers may be installed with fire walls between banks of two or three units or, if larger and more important transformers, between individual units. One company has recently adopted the policy, on large outdoor transformers, of eliminating the column-type oil gage from the conservator and of installing fuse-releasing gravity-closing valves on all connections between conservator and main tank. It is intended by this policy to prevent the spreading of possible transformer fires by the release of the large quantity of oil contained in the conservator, as sometimes happens through the cracking of the gage glass on the occurrence of fire in the immediately adjacent transformer and through the feeding out of burning oil from a rupture in the cover of a faulty transformer.

Both indoors and outdoors, fire isolation may be augmented by the installation of pits and drainage systems properly disposed with respect to oil-immersed transformers and regulators and oil circuit breakers.

The third form of fire protection, means of fighting the actual fire, divides naturally between the use of liquids and the use of gases. The most obvious liquid for this purpose is water, which is often piped to the end-bells of large rotating machinery and may be used elsewhere in connection with one of the commercial sprinkler systems; there is, however, considerable question as to the efficacy of water as a means of fighting oil fires. Other liquids take the form of special preparations, often generated on the premises at the time of fire, either by the mixture of two liquids or of water and a powder. Gaseous means are limited commercially to the use of carbon dioxide, which is heavier than oxygen and serves to smother the fire when applied in sufficient concentration; it is therefore particularly suitable in confined spaces where liquid might damage the apparatus and/or where the gases emanating from some of the commercial liquid preparations would be obnoxious. The efficacy of all these fire-fighting fluids may be considerably increased by the installation of permanent piping, designed to permit the direction of the fluid at the most advantageous point in case of fire. Whether or not the valves of this piping should be automatically operated depends not only upon the importance of the installation and the liability of a large fire, but also upon the proximity to a central attended installation and the attendant costs of automatic equipment for fire alarm as compared with the costs of automatic equipment for fire fighting in the unattended station.

It is believed that the art of fire protection is developing so rapidly, particularly in connection with unattended automatic stations, that no standards should be promulgated at this time by the American Institute of Electrical Engineers or others. It is thought that only by giving comparatively free rein can it be assured that progress will continue to be made in accordance with the best economic dictates.

The attached Appendix A is a preliminary attempt to classify for further investigation or study, I. the causes

of fires, II. the spreading of fires, III. preventive measures, and IV. the extinguishing of fires.

Appendix A

I. Causes of Fires. II. Spreading of Fires. III. Preventive Measures. IV. Extinguishing of Fires.

I—Causes of Fires

A. Faulty Design
1. Insufficient spacing.
2. No allowance for temperature changes.
3. Reduced clearances from distortion due to short circuits.
4. Conductors or equipment improperly or insecurely supported.
5. Weakness of mechanical structure or supports.
6. Insufficient provision against heaving by frost, entrance of rain, or accumulation of sleet.
7. Cannon construction (by cannon construction is meant the arrangement of barriers or compartments in such a manner as to direct an arc outward into other equipment or into operating aisles).

B. Faulty Equipment
1. Improper design.
2. Poor material.
3. Defective materials or parts.
4. Insufficient insulation, spacing of parts, strength or thermal capacity.
5. Improper assembly.
6. Improper and insufficient testing.
7. Unnoticed failures as a result of testing.

C. Improper Application of Equipment
1. Wrong material—moisture absorbing, subject to chemical change.
2. Wrong apparatus—type, size, rating.

D. Aging of Apparatus and Material
1. Deterioration of insulating material on conductors, supports, windings.
2. Corrosion of metals from action of air, moisture, electrolysis.
3. Effect of moisture, gases and corona in hastening deterioration.

E. Static Stresses
1. Causing destruction of insulation.
2. Collecting conducting material.

F. Magnetic Stresses
1. Mechanical movement.
2. Collecting conducting material.

G. Surges or Lightning
1. Atmospheric conditions.
2. Switching operations.
3. Improper grounding.

H. Arcs (other than flashovers)
1. Switching operations.
2. Contactors.
3. Commutators.

I. Exceeded Ratings
1. Exceeded current rating, overload.
2. Overvoltage.
3. Exceeded temperature rating.
4. Exceeded time.

J. Errors in Operation

K. Failure of Apparatus Containing Oil
(This includes oil circuit breakers, oil switches, transformers, pot-heads, etc.)
1. Insufficient amount of oil.
2. Surplus amount of oil.
3. Slopping of oil (mufflers, discharges).
4. Dripping of oil on other apparatus.
5. Lowering of oil level due to leaks, syphoning or intense cold.
6. Freezing of oil.
7. Carbonization of oil.
8. Presence of moisture.
9. Explosions due to arcs following short circuits.
10. Poor contact.
11. Puncture of bushing.
12. Internal corona discharges.
13. Internal earth fault.
14. Internal short circuit.
15. Phase interruptions due to mechanical failures.
16. Short-circuited laminations.
(Note: See other sections for failure of apparatus in general).

L. Exposure to External Attack
1. Animals—birds, rats, nests, etc.
2. Foreign material thrown on equipment—stones, kite strings, airplanes.

M. Dirty Apparatus
1. Dirt from coal piles, or adjacent industries.
2. Boring action of metallic slivers.
3. Causing reduced radiation.
4. Causing flashovers.

N. Spontaneous Combustion
1. Oily waste or rags
2. Coal.

O. Friction
1. Lack of lubrication.
2. Improper alinement.
3. Dirt.

P. Condensation
1. Unheated conditions.
2. Temperature changes in conduits.
3. Unventilated conditions.
4. Wrong materials.

Q. Heating Equipment and Piping
1. Failure of electrical heaters.
2. Defective flues.
3. Explosions of oil burners.
4. Escaping steam or water from pipes.
5. Broken fuel lines.

R. Carelessness
1. Improper tagging or operation (disconnects, etc.).
2. Cigarettes, matches.

S. Atmoshperic Conditions
1. Flashovers due to fogs, especially salt water fogs.
2. Sleet or wind.

T. Exterior Fires
1. Adjacent buildings.
2. Grass and forest fires.

II—Spreading of Fires

A. Inflammable Material in Apparatus
1. Insulating material in conductors, such as rubber and varnished cambric.
2. Insulating supports or braces, such as wood.
3. Oil or inflammable compounds.

B. Inflammable Material in Construction
1. Wooden buildings, compartments, or structures.
2. Forms used during construction.

C. Insufficient Segregation
1. Insufficient barriers, compartments, cells or rooms.
2. Insufficient spacing between types or classes of apparatus.
3. Improper grouping of equipment, wiring, etc.
4. Improper drainage of oil, etc.

D. Poor Housekeeping
1. Rubbish during construction
2. Accumulation of rubbish in operation.
3. Storage of inflammable material.

E. Fanning Action of Ventilating Equipment.
F. Lack of fire Extinguishing Apparatus.
G. Failure to Announce Start of Fire, Smoke or Heat.

III—Preventive Measures

A. Use of fire-proof or fire-resisting material in construction.
B. Elimination of oil so far as possible.
C. Keeping premises and apparatus clean.
D. Segregation of apparatus.
E. Correct design or application.
F. Constant expert supervision.
G. Careful inspection before and during installation.
H. Periodic testing.

IV—Extinguishing of Fires

A. Detection.
B. Alarms.
C. Accessibility.
D. Automatic fire extinguishers—classification and suitability of each type.
E. Hand-operated extinguishers—classification and suitability of each type.
F. Drainage of burning oil.

Wire Designations

Contributed by O. J. Rotty and M. E. Reagan.

The development of a uniform scheme of wire designations for station control wiring has been given some study with the idea that if a satisfactory scheme could be devised it should be offered for standardization.

The general use of such a scheme would produce uniform marking of control wiring at all stations regardless of whether the panels were wired by different manufacturers or by the user himself. This seems desirable for many reasons. The engineer laying out a new station or an extension to an old one would have to be familiar with only one scheme of wire designations and if the apparatus for a particular station was supplied by a number of manufacturers the wire designations would be alike for all the apparatus, resulting in simplification of interconnecting wires and common circuits. These points are also of importance to the construction or installation men, to the testing men, maintenance men, trouble shooters, etc.

At present there are many schemes in use, with each manufacturer and many utilities and engineering organizations having their own schemes all of which are different although some may have certain features in common. There seem to be many reasons why each scheme is preferred by its sponsor and why other schemes are objectionable. However, it is felt that a scheme can be devised which will fulfill practically all requirements and overcome the more important objections. The standard scheme must be of a general nature and must be applicable to all kinds of stations; *viz.*, railway, Edison, mining, hydro, a-c. distribution, and even steam plants.

There is a number of points in the designation of wires on which there is fairly general agreement. These are briefly as follows: 1. The scheme should be simple, easily understood and applied and with few special cases or exceptions; 2. it should be flexible so as to permit of additions or changes to the control without completely revising the existing designations; 3. it should provide the "tie-in" with or reference between the actual wire and the diagrams (either the wiring diagram, the schematic diagram, or both); 4. the wire designations should appear on the schematic (or elementary) diagram.

It also seems desirable that certain other ideas be worked into the standard scheme, which are briefly as follows: 1. The wire designation should be made up of as few digits as possible; 2. it should not be a complicated combination of letters and numbers; 3. it should preferably have some significance as to the apparatus or panel the wire connects to, although this appears to be difficult to devise and very likely an arbitrary scheme will be finally adopted; 4. operating and control buses and circuits of the nature of buses should be included in the standard scheme.

This subject has been taken up by this committee only recently and the time has been insufficient for the development of a finished scheme. However, it is felt that the work should be continued by the succeeding committee.

Several closely allied subjects have presented themselves for investigation but lack of time has prevented work upon them. They are: 1 Wire group or conduit designations or numbers, and 2, wire color codes. It is felt that these should also be given some study with a view to suggesting standards for them.

Research

Contributed by M. E. Reagan.

Research items to be studied and followed by the committee are divided under four main divisions. One object of investigation is to assemble data on operation while another object is to establish the trend of automatic expansion in operation. For instance, in the use of vacuum gas filled tubes in power and control systems, it will be the function of this committee to carefully record the various applications and keep experience charts showing the growth of usefulness and their performance.

The four general classifications are as follows:

I. Automatic Control of Rotating Machines (including mercury arc rectifiers).
   a. Synchronous converters.
   b. Motor-generator sets.
   c. Mercury-arc rectifiers.
   d. Hydro-electric generators.
   e. Frequency-changers.
   f. Synchronous condensers.
   g. Balancer sets.
   h. Battery chargers
      1. Automatic end cell switches.

II. Automatic Control of Static Machines.
   a. A-c. transformer substations.
   b. Periodic reclosing feeders.
   c. Static condensers.

III. Network Protectors.

IV. Supervisory Control.
   a. Terminal apparatus.
   b. Channels.
      1. Fused lines.
      2. Private.
      3. Carrier, etc.

Suggested Items.
   a. Curve of total installations by years.
   b. Curve of total kva. by years.
   c. Curve of per cent automatic to manual installation by years.
   d. Curve showing rehabilitation of old units for automatic service.
   e. Curve showing per cent availability by years.
   f. Data on primary causes of outages, such as
      1. Line trouble.
      2. Main apparatus trouble.
      3. Control trouble.
      4. Due to testers or maintenance man.
   g. Performance data on fuses in control circuits.
   h. Ventilation as it affects "sweating" of apparatus.
   i. General field testing of equipment expand last year's report.
   j. Data on vacuum tube applications of all types in control work.

Telemetering in Connection with Load Dispatching

Contributed by A. M. Garrett and J. J. Samson.

In order that electrical systems, particularly those of the public utility and traction companies, function with the highest degree of service standard and efficiency, it is necessary that the control of certain system operations be centralized.

Such operating knowledge and duties as restoration of the service to normal during or following a case of system trouble; the interchange of energy between systems or parts of the same system; switching in and out of service of generating station or substation units in accordance with load demands; the load quantities

existing in different parts of the system; the maintenance of proper voltage, frequency, temperature of equipment; adjusting the system to take care of construction work in connection with system extensions, maintenance and repairs, are some of the functions that must come under the guidance of this group.

The majority of these functions is under the control of the load dispatcher or system operator who depends upon his knowledge of the operating condition of the system through the forces which actually operate it. This information comes to him in the nature of a periodic check, generally by telephone.

In recent years as the system developed through growth and expansion, and in some instances through combination, the problems associated with the handling of these systems become more involved, so that the need for quicker and more accurate information as to the operating status of the system became apparent. In order to handle the situation intelligently, a continuous record or "running account" so to speak was needed instead of a periodic sampling of conditions. To meet these requirements telemetering or remote indication equipment has been developed and placed in service in many systems in this country in the past five years. To take care of these problems under the old method would mean quite a material increase in the load dispatchers' force.

Telemetering is a means of transmitting to a central control point over a communicating circuit or special conductors, information necessary for the operation of the equipment, station or system. This may be electrical quantities (volts, amperes, watts, power factor), temperature, position of breakers, regulators, or any other information that it may be desired to obtain from the system.

It consists essentially of a transmitter at the remote end connected to the equipment from which information is desired, a receiver at the control end and the connecting circuit. The quantity of energy to be measured or position of equipment to be indicated is converted to a voltage and current (suitable for telephone cable) whose value is proportional and is transmitted to the receiver which is calibrated to record the information.

With a view to determining the trend of telemetering devices and methods, the committee decided that a survey in the form of a questionnaire should be made of those companies now operating this class of equipment.

The questionnaire covered the following points:

1. What of the following do you use telemetering for?
   Totalizing load.
   Current and voltage conditions.
   Temperature of equipment.
   Position of switch gear.
   Tap changer and regulator positions.
   Uses other than above.
2. State briefly the type of system and the principles of operation.
3. What channels are used?
   Telephone lines.
   Transmission lines.
   Special conductors.
   State approximate distances of transmission.
4. Is this system of aid in load dispatching?
   In what manner?
5. What criticism do you have of telemetering?
6. What, in your opinion, is the trend of development?

The term "load dispatching" is understood to cover broadly the function of load control and switching operation which is dependent upon telemetering information.

This survey has just been completed and a total of 35 companies canvassed. The following information has been compiled:

Under uses or application we found approximately 40 per cent of the companies use the equipment for determination of current and voltage conditions, while 22 per cent of the installations were for totalizing load and 18 per cent were for position indication of equipment.

Under types used, there seems to be a general use of direct current either in the form of balanced current or rectified current.

As the connecting circuit between the remote end and the receiving end, about 30 per cent used active telephone circuits, while the remaining 60 per cent used special conductors. The distance of transmission varies from 500 feet to 15 miles with no special average.

In answer to the direct question of whether the system was an aid in load dispatching, 60 per cent stated that it was, while the rest of the replies gave no opinion or indicated lack of experience due to the short time the equipment had been in service.

In reply to the inquiry on criticism of the equipment, the survey showed little or no adverse expression. One point emphasized was the lack of high speed response with accuracy comparable to the usual line of switchboard indicating instruments. There is a tendency where high speed is desired to sacrifice somewhat the matter of accuracy. Another criticism was on the cost basis, the installed cost of the equipment running into "considerable money." Especially is this true where special conductors are required over long transmitting distances.

Improvements toward simplification of the present complicated equipment, as means to greater reliability, was offered as one criticism.

On trend of development, practically all replies indicated a favorable reaction to future development, especially where extension to the system was in prospect. This applies particularly to the situation where interconnection is concerned. One reply mentioned there would be no future development for telemetering in this company as the type of distribution was being changed to an a-c. network whereby the substation would be eliminated.

In general, it can be stated that telemetering has established itself, and with extension of load control and switching operations made necessary through an increase in the size of systems, in interconnection between systems, and constantly increasing number of unattended stations, telemetering is proving a distinct aid in the solution of those problems of handling and operating an electric system.

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Communication

ANNUAL REPORT OF THE COMMITTEE ON COMMUNICATION*

IN accordance with the usual practise, this committee submits herewith a brief review of the developments during 1930 in electrical communication.

Telephone Service Improvements

Telephone service was improved during the year by the application of new developments and methods and improved maintenance. The average time to complete toll calls was lowered by 12 seconds to an average of one minute. Improved maintenance methods have reduced the frequency of troubles affecting subscribers' lines so that a trouble now occurs on the average but once in 22 months, a reduction in trouble frequency of about 11 per cent as compared with 1929.

Steady advancement in the quality of speech transmission was accomplished. On the longer haul toll business, unsatisfactory transmission conditions were experienced on only 1.5 per cent of the messages, compared with 1.7 per cent in 1929. One of the important factors contributing to this improvement was the institution of a more effective method for controlling the amplification of speech on toll calls involving two or more long circuits. An improved general plan for the design and rearrangement of plant to handle calls between remote points not connected by direct circuits was adopted. Under this plan, the number of intermediate switches is minimized with a consequent improvement in speed, accuracy, directness of routing, and transmission. A paper describing this plan, by Mr. H. S. Osborne, was presented at the 1930 Summer Convention. (A. I. E. E. Trans., October 1930.)

Subscriber's Equipment and Services

During 1930 the number of hand telephone sets in service increased to approximately 2,000,000 as against about 1,000,000 at the beginning of the year. The development of a type of hand set which would meet the electric and acoustic requirements of telephone practise in this country has involved the solution of difficult technical problems. These problems have been concerned primarily with the suppression of singing, for which the hand set has a tendency because of the rigid connection of the transmitter and receiver, and with the efficient operation of the transmitter in a wide range of angular positions. These difficulties have been successfully overcome through the application of a large amount of scientific work in the design of the hand set handle, the transmitting and receiving elements, and the electrical circuit connecting them. These achievements have made it possible to use the hand set without any sacrifice in performance as compared with the desk stand set.

For subscribers requiring a large number of attendants to take messages or orders, there has been made available an automatic call distributing arrangement associated with a simple type of attendant's position, whereby calls are immediately connected to idle attendants or, if none are available, are held and subsequently connected in the order in which they arrived.

A new type of private branch exchange suitable for larger residences and business offices of moderate size was made available during the year. No operator or attendant is required. Calls may be originated, answered, and transferred from any of the telephones. Intercommunicating calls are made by means of the dial. Complete privacy for both outside and intercommunicating connections is provided.

While arrangements have been available for some time for private branch exchanges whereby a number of telephones could be connected together simultaneously in a conference connection, these arrangements have been extended during the past year so as to enable the interconnection of a larger number of stations and to include more than one trunk circuit out of the private branch exchange.

Central Office Systems and Apparatus

During 1930 there was an increase of about 1,000,000 dial stations, bringing the total to approximately 5,565,000, or more than one-fourth of the total number of stations in this country. Besides the conversion to dial of additional portions of large cities, increasing use has been made of dial equipment in small communities where services requiring the assistance of operators can economically be handled from near-by centers.

Further extensions have been made in the mechanical tandem facilities used primarily for service between the larger areas and neighboring suburban points. Arrangements are now in service for automatically inserting voice repeaters when required on calls between

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the more distant points. Facilities are also included for completing calls to a variety of types of offices, either mechanically or by key sets at call distributing tandem positions. An installation of call announcer apparatus, described in last year's report, has been made in New York. The mechanical tandem also includes a trouble recorder which provides a continuous count of calls affected by various classes of irregularities and prints, by means of a teletypewriter, a complete record of the channels and equipment used by such calls.

The panel system has been provided with a new type of equipment known as the decoder for translating the digits dialed by the subscriber into the electrical information required for routing the call to various types of offices. Panel equipment in certain areas is also being arranged to permit subscribers to dial calls directly to distant zones which previously required the supervision of an operator because of the additional charges involved. The equipment is arranged to determine the number of message units corresponding to the charge to the zone in which the call terminates and to cause a corresponding number of operations of the message register.

Time announcement systems for use in the larger areas have been modified by the addition of facilities for the distribution of announcements over a trunk network, equipped with repeaters to insure adequate volume and quality, so that one operator may furnish time announcements for a network of offices.

An improved low-speed interrupter, utilizing mercury make and break contacts, has been developed for use in giving flashing signals to operators and in timing sequence operations. For producing tones used as signals to operators and subscribers, there has been developed an alternator which enables close control of the frequency, magnitude, and harmonic content of the tones. The field windings and the tone output windings of this alternator are formed on the stator, and the tone is produced by an unwound, toothed rotor which varies the magnetic flux in the tone windings.

Privacy apparatus was put into service during the year on nearly all of the intercontinental radio telephone circuits operated out of this country. By means of this apparatus the radio waves transmitting conversations are so modified in their characteristics that if listened to with an ordinary radio set, speech is not intelligible. At the receiving end this process is reversed and intelligible speech restored. While this does not guarantee complete secrecy, it does furnish a considerable degree of privacy and represents an important step in advance.

Another important toll equipment development was a new type of toll switchboard in which the use of smaller jacks makes possible a substantial increase in the number of trunks and toll lines appearing at each toll operator's position. Tandem positions are also provided through which an operator may secure access to any circuit not appearing in the toll line multiple at her position.

Outside Plant Construction and Methods

To facilitate the placing of tape armored toll telephone cables, a method has been developed whereby the trenching, laying of the cable, and the filling of the trench are simultaneously accomplished in one operation. This method utilizes a tractor behind which are pulled the trailer supporting the cable reel, the plow, and the drag which fills in the trench. From the reel, the cable is threaded through a pipe which leads it to the trench at a point directly in back of the plow. Under ordinary conditions it has been practicable, on the average, to lay more than one mile of cable per day with one outfit, using this method.

A new method which utilizes a single tube sleeve has been developed for making joints in aerial line wire. A hand operated rolling tool compresses the sleeve onto the wire in such a way as to provide a joint with no greater electrical resistance than a corresponding length of line wire and with a tensile strength at least equal to that of the wire. This new joint is expected to avert the electrical troubles now experienced with open-wire joints of the twisted sleeve type.

An important step has been taken by the communication interests cooperating with other pole using utilities, and others connected with the pole industry, in arriving at uniform classification dimensions for wood poles of southern yellow pine, western red cedar, northern white cedar, and chestnut. This work was carried on by the American Standards Association. Standard fiber strengths lb. per sq. in. have been established as follows: 7,400 for southern yellow pine, 5,600 for western red cedar, 3,600 for northern white cedar, and 6,000 for chestnut. These values have been accepted and made American Standards.

Under the new classification, a pole of a given class designation will have approximately the same breaking load regardless of pole length and species of timber. The adoption of the new grouping by all users of wood poles is expected to result in economies in the production and stocking of poles. The problems introduced by joint use will also be simplified as both parties to the joint use agreement will be using the same classification, whereas in the past this was seldom the case. Cost comparisons between the various species can be more easily made under the new classifications as prices may be directly compared class for class, whereas under the old tables calculations had to be made to determine the class of equivalent poles of other species of timber.

Long Distance Toll Cables

About 5,000 miles of cable for toll use were added to the telephone system of this country in 1930, bringing the total toll cable mileage to approximately 24,000 miles. Including the toll cable network on the Pacific Coast, which is connected with the toll cable network of the rest of the country by several individual and widely separated open-wire toll routes, there are now 129 out of 176 cities of the country having populations

of 50,000 or more connected directly into the toll cable network. The fourth telephone cable between Key West and Havana was completed in January 1931. The new cable is non-loaded and employs the recently developed paragutta insulation. It is equipped with carrier telephone apparatus which now provides three telephone message circuits, as well as one d-c. telegraph circuit. Provision has been made for the addition of other telephone circuits when needed. The telephone facilities now afforded by the single new cable are equal to those furnished by the three older cables in total. This gain in efficiency is brought about by improvements in the art of cable construction, including employment of paragutta, as well as advances in the application of carrier methods using high frequencies for multiplexing.

About 35,000 miles of telephone circuit are now being regularly utilized for radio program transmission service and almost 200 radio broadcasting stations receive programs from these chains of wire circuits. Heretofore practically all of this service has been furnished by means of open wires using voice-frequency channels. However, a new type of circuit for toll cables has recently been developed which permits of transmission over long distances without material distortion of a frequency range from 50 to 8,000 cycles, at the same time transmitting a volume range of about 40 db. (energy ratio 10,000 to 1). These characteristics are desirable for the satisfactory transmission of music where the frequency and volume range requirements are much greater than in the case of speech. This new type of cable circuit is loaded at 3,000-ft. intervals and special repeaters are placed at approximately 50-mile intervals. Associated with each repeater is an attenuation equalizer and a delay equalizer, which correct for the attenuation and delay differences at different frequencies. A paper on this subject, by Messrs. A. B. Clark and C. W. Green, was presented at the 1930 Summer Convention (A. I. E. E. TRANS., October 1930, p. 1514.)

CARRIER TELEPHONE AND TELEGRAPH

During 1930 about 160,000 channel miles of carrier telephone facilities and 400,000 channel miles of carrier telegraph facilities were installed in the United States. Recent improvements of carrier circuits involve improved transposition arrangements and the introduction of 8-in. spacing of wires in place of the 12-in. spacing. This latter development permits an increase in the number of facilities obtainable from a given number of wires on a pole line.

The operation of voice-frequency carrier telegraph over the channels of high-frequency carrier telephone systems has been successfully applied. For example, each of the three two-way channels of a carrier telephone system has been filled with 12 carrier telegraph channels. Such a pair of wires accommodates a duplex d-c. telegraph circuit, an ordinary two-way message telephone circuit and 36 duplex carrier telegraph channels which if multiplexed would afford means for the transmission of about 7,500 words per minute for the telegraph facilities alone.

A paper by Mr. E. I. Green, discussing the transmission characteristics of open-wire telephone lines, and a paper by Mr. L. T. Wilson, discussing telephone line insulators, were presented at the 1930 Summer Convention. (A. I. E. E. TRANS., October 1930.)

INTERCONTINENTAL TELEPHONY

Most notable of the advances made during 1930 in the intercontinental telephone field was the opening on April 3 of service to South America. This service is provided by a short-wave radio circuit operating between the transmitting and receiving stations at Lawrenceville and Netcong, New Jersey, and corresponding stations near Buenos Aires, Argentina. The ratio portion of this circuit is 5,300 miles in length and it is therefore, the longest circuit now operating from the North American continent. The transmission characteristics of this circuit are, however, somewhat better than those of the short-wave circuits between the United States and England, due principally to the fact that the transmission path of the South American circuit is further removed than is that of the North Atlantic circuit from the polar regions and the adverse influences of magnetic storms. Furthermore, the South American circuit, running nearly along the meridian, experiences a more uniform condition as to daylight or darkness. As a result of these factors, extreme variations in transmission, which form an important problem on the east- and west-bound radio circuits, are materially reduced on this circuit.

At Buenos Aires the radio circuit connects with wire and cable circuits to more than 325,000 telephones in the Argentine Republic, Chile, and Uruguay, including the cities of Santiago and Montevideo.

Another feature of interest during the year was the establishment of radio communication between the United States and Australia by way of London. At London the transatlantic circuits are connected to a London-Sydney short-wave radio circuit, which at Sydney connects in turn with the wire network of the Australian Telephone Administration. This combined circuit is approximately 14,000 miles in length.

Four papers, discussing transoceanic telephone service in its various aspects, were presented at the 1930 Winter Convention by Messrs. T. G. Miller, Ralph Bown, A. A. Oswald, and F. A. Cowan.

By the end of 1930, many parts of the world had been linked together by radio-telephone circuits in addition to those mentioned above. Most of these circuits have one end in Europe, far ends in such distant places as Brazil, Argentina, Australia, New Zealand, Siam, Indo-China, Java, and Algiers. Not all of these circuits are yet connected with the telephone systems at their terminals, and they do not all, therefore, possess to the same degree the universal accessibility and utility of those radiating from North America.

Ship-to-Shore Radio-Telephone Systems

A novel type of ship-to-shore service was inaugurated in the middle of the year through the equipment with radio-telephone apparatus of a New York City fire-boat. This equipment is arranged to enable continuous two-way telephone service between the master of the fire-boat and his land headquarters when the boat is under way. By means of this close communication, it has been possible to coordinate the efforts of the land and marine fire forces more effectively. As a result of the demand for telephone service of this kind in important harbors, both for harbor craft and ocean-going vessels, plans have been made for opening to such service in 1931, radio-telephone stations at Los Angeles, San Francisco, Puget Sound, and New York.

Commercial telephone service between ships at sea and the telephone system of the United States was extended during 1930 so that this service is now available to five ships: the Leviathan, Majestic, Homeric, Olympic, and Belgenland. Several organizations are involved in the provision of this service: the International Marine Radio Company, a subsidiary of the International Telephone and Telegraph Company, the Marconi Company, and the American Telephone and Telegraph Company. The shore stations are operated by the American Telephone and Telegraph Company on this side and by the British Post Office on the European side. During 1930, construction of a new land station at Ocean Gate, New Jersey, to care for transmission from shore to ship was completed. As in all radio-telephone transmitting stations, the antennas at this new station have a marked directional characteristic, the transmitted waves in this case being directed so as to traverse the North Atlantic shipping lanes. Four different wavelengths are used for transmission, ranging between 17.5 and 63 meters. Generally speaking, reliable transmission has been obtainable at distances from New York up to about 1,000 miles, corresponding with two days' sail. While satisfactory talks have been made at distances of 2,500 miles or greater, transmission at such distances has not been uniformly good.

A paper by Messrs. William Wilson and Lloyd Espenschied, discussing radio-telephone service to ships at sea was presented at the Northeastern District Meeting in May 1930.

Telegraphy

During 1930 all Western Union tickers handling New York Stock Exchange service in the United States were converted to the high-speed type. This permitted increasing the output of stock quotations from 300 to 500 characters per minute. In the field of telegraphic distribution of quotations and other market information, many improvements in apparatus and methods of operation were developed and applied during the year which resulted in a reduction of manual handling, greater output and extended operation into territory not heretofore reached, including quotation service to Cuba.

There has been a considerable expansion during the past year in the use of automatic quotation boards for electrically indicating market prices and this service has been extended to a number of other cities in addition to New York, where the first boards were installed.

Numerous additional installations have been made of concentration equipment for printing telegraph circuits. A description of the apparatus used for this purpose is contained in the paper entitled *A Printing Telegraph Concentrator* presented by Mr. W. B. Blanton at the Winter Convention in January 1931.

The Western Union Telegraph Company has developed a method whereby channels of a multiplex system circuit may be automatically repeated and extended individually over single wires by means of simplex printers to offices. Circuits from several offices using simplex printers may be grouped at a central point and combined into a multiplex circuit to a distant central office. This system will give many small offices direct outlets to the large centers which could not have been economically provided with previous methods.

During the year there was a marked increase in the tendency to employ, in place of direct current telegraph to outlying points superposed on telephone circuits, a method of operation which is called "two-path polar operation." This involves the use of independent one-way polar circuits for the two directions and affords improved service with a lower maintenance cost as compared to the usual polar duplex method.

Several methods of measuring the quality of telegraph transmission have been developed. One form of apparatus which has been found very effective both in the laboratory and the field was described by Mr. F. B. Bramhall in a paper entitled *Telegraph Transmission Testing Machine*, presented at the 1931 Winter Convention.

A paper describing various technical features in connection with the submarine high-speed duplex telegraph cable between Bay Roberts, Newfoundland and Horta, Azores was presented at the Winter Convention in 1931 by Messrs. J. W. Milnor and G. A. Randall. At the same convention, Mr. Milnor presented a paper on the influence of interference in submarine cables.

In addition to the statewide police teletypewriter systems in Connecticut and Pennsylvania, an extensive system of about 30 stations was installed last year in New Jersey for the New Jersey State Police. There is an increasing number of large city police networks, such as those of New York City, Boston, Buffalo, and St. Louis. The United States Coast Guard also has such a system in use along the New England Coast.

Progress has been made in the development of switchboards for teletypewriter service to permit the interconnection of these machines in a manner similar to that by which telephone instruments are interconnected.

A new type of belt conveyer has been developed by

the Western Union Telegraph Company for carrying telegrams between the various parts of the central office. In this conveyer messages are carried along between a steel channel and a moving flat belt about 1¾ in. wide, the motion of the messages being due to their sliding along the steel channel with practically no friction while adhering quite firmly to the belt. The messages can be taken around vertical or horizontal turns as well as through vertical and horizontal twists.

Municipal and Protective Signaling

There has been a steady increase in the use of electrical traffic signals. In the larger cities there have been several installations of flexible progressive systems, while in smaller places and in outlying sections of the larger cities, the detached intersection type of signal is still largely used. For important intersections and through traffic highways, vehicle controlled signals have been fairly successful but are expensive to install and maintain, as compared with the predetermined period signals. Vehicle control of signals obtained otherwise than by switches imbedded in the street surface, such as light beam control, has been tried out.

There has been a considerable use of electrical caution flashers in place of earlier types employing compressed gas, and practically all new installations are electrical. More illuminated caution signs are being installed and cheaper methods of illumination than by the neon tube method are being investigated

An important development of the past year concerning municipal fire alarms, has been the production of signal boxes and central office control apparatus, making effective use of ground return to send in alarms at such times as the circuit is in abnormal condition. Previous attempts to accomplish this introduced some abnormal condition on an otherwise normal circuit. This defect has now been practically overcome, and signal boxes have been developed that will operate in the usual manner on a normal circuit while at the same time they will transmit signals over a grounded, short-circuited or broken circuit without the necessity of making any temporary alterations at the signal box. While this development is too recent to be able to judge of its effects, it may permit of more leeway in circuit construction than is now considered safe, such as the installation of both sides of a circuit in the same aerial cable. The importance of this improvement may be estimated when it is considered that fires often occur at times when circuit conditions are apt to be disturbed by storm, explosion, or accident.

The use of single battery with trickle charger in place of duplicate batteries charged alternately by motor-generators is increasing with consequent increase in battery life.

The use of rectifiers and floating batteries or of transformers and a-c. circuits in connection with institutional fire alarms has progressed to such an extent that practically all new installations make use of public electric supply for the operating current in preference to primary batteries or to storage batteries charged from motor-generators. The practise of connecting automatic sprinkler alarm valves to municipal fire alarm boxes so that an alarm will be sounded automatically for any appreciable flow of water, has spread.

Experiments have been made on improved flash-light mechanisms for calling patrolmen to signal boxes. One such system has been installed lately in Boston. This permits any citizen desiring to call a policeman to operate an exposed lever which starts the flash-lights blinking the number of the signal box from which the call is made.

Television

Further advance was made in television as an accessory of telephone conversations by the development of means whereby two people at a distance are enabled both to converse and to see one another as if seated face to face in the same room. One of the interesting problems encountered in this development was that of sufficiently illuminating the faces of the parties engaged so that their images could be transmitted without, at the same time, dazzling their eyes to such an extent that they would be unable to see before them the image of the other party. This difficulty is met by employing blue light for scanning the faces of the parties. While the eyes are relatively insensitive to this color, the photoelectric cells used to pick up the light reflected from the face and generate the television signals are highly sensitive to it. Concealed microphones and loud speakers connected by four-wire telephone circuits are used in place of conventional telephone instruments to provide the talking portion of the system. The problem of operating a loud speaker and a sensitive microphone in the same small booth in such a manner that a self-sustaining singing circuit would not be created has been solved by specially treating the walls of the booth to prevent the reflection of sounds into the transmitter and by so locating both transmitter and loud speaker that the transfer of sound between them is minimized. While the experimental system is only two miles long, the television apparatus will function satisfactorily over distances of hundreds of miles when connected by suitable circuits as was shown by the one-way demonstration between New York and Washington.

Three papers dealing with television, by Messrs. H. E. Ives, F. Gray, M. W. Baldwin, H. M. Stoller, D. G. Blattner, and L. G. Bostwick, were presented at the 1930 Summer Convention. (A. I. E. E. Trans., Oct. 1930.)

Airplane Radio-Telephony

Development of telephone communication with airplanes continues to progress, and it has been found to be of very great importance for communication between transport planes and ground stations. Two-way radio-telephone apparatus for communication between planes

and ground has been developed and supplied for equipping a comparatively large number of planes. The value of such equipment may be indicated by the fact that legislation provides for increased revenue to air mail contractors flying planes equipped for two-way radio communication

Two papers on this subject were presented during the year, one by Mr. R. H. Freeman at the Pacific Coast Convention, the other by Mr. Eugene Sibley at the Middle Eastern District Meeting in October.

Synchronizing Radio Broadcasting Stations

There has been considerable experimental work carried on during the past year by the prominent radio organizations along the line of synchronizing broadcasting stations so that the same radio program may be broadcast from different stations operating at the same frequency. Best results are obtained only with a high degree of synchronism between the carrier frequencies of the different radio stations. In certain of the more successful experiments the control of the radio station frequencies has been carried out by sending over wire circuits standard frequencies of 4,000 or 5,000 cycles which, at the radio stations, are stepped up and used either directly to provide the radio carrier or indirectly to control the frequency of a local oscillator. While it is evident from the tests which were made that line circuits can be used very satisfactorily for transmitting control frequencies, certain requirements are imposed on the radio station frequency step-up equipment to iron out minor line fluctuations, which are, of course, greatly exaggerated when the frequency is raised from the relatively low frequency transmitted over the lines to the radio frequency of from 500 to 1,000 kilocycles.

Standardization of Radio Terms

During the past two years the Standardization Committee of the Institute of Radio Engineers has had under way a complete revision of definitions of terms, abbreviations, symbols, and methods of measurements and tests. A preliminary report of this work was issued in December, 1930.

Foreign Communication Matters of Interest

During the year international service was extended in Central America by the interconnection of Guatemala and El Salvador. In Mexico the subscribers of a second large network were given access to the United States and all points reached therefrom.

Conference toll service or multiple telephone service was established in the Netherlands. By means of this system from three to six subscribers in the same or different cities may be interconnected at the same time so that any one of the subscribers may be heard by all of the others.

Picture transmission service was extended in a number of countries, particularly in Japan.

In Europe the toll cable network was increased during the year by 6,000 to 8,000 kilometers. Two additional submarine cables were placed across the English Channel and one was placed between Sweden and Germany.

A complete rotary automatic exchange system was installed in Vatican City and connections were established with the international network.

Direct dialing over long distance telephone lines was successfully demonstrated in Europe and installations were made in several countries. Toll dialing has been employed in the United States to a limited extent for a number of years.

Transatlantic radio-telephone service was extended to include a number of new countries in Europe and to reach additional points in countries to which service had previously been given. Connections to points within the Antarctic Circle became possible for the first time when the service was extended in South America to include a number of additional cities in Argentina and Chile.

During the year the International Telephone and Telegraph Corporation, in cooperation with the government administrations concerned, opened direct radio-telephone links connecting Buenos Aires with Paris, Berlin, and London. These additional links between South America and Europe not only decrease the use of long land lines formerly required to serve points distant from the radio terminal, but greatly increase the reliability of the international connections as a whole. When, because of atmospheric disturbances or for other reasons, one link is unable to give commercial service, the traffic may be routed over one of the other links. The question of allotting the traffic over the different circuits and adjusting rates so that the rate between two points will not depend upon the routing of the call has been by no means a simple one, but with the cooperation of the various government administrations much progress has been made.

Commercial service was made available between telephone subscribers in Chile, Uruguay, and Argentina, and subscribers in Belgium, Denmark, Switzerland, Austria, Lithuania, Poland, Esthonia, Norway, Sweden, Czechoslovakia, and Jugoslavia through one or another of the four direct links from Buenos Aires which, of course, also serve Spain, France, Germany, and Great Britain.

Commercial telephone service was opened to some of the Canadian National Railway express trains and equipment for the reception of broadcast programs on moving trains was provided in a number of countries, including Jugoslavia, Italy, and Austria.

During the year technical development work continued to prepare for improvements in existing apparatus and methods as well as to explore new fields, such as signaling and dialing over radio-telephone circuits, and the use of the so-called ultra short waves, those of under five meters.

Cooperation Between Wire Using Companies

The many problems arising in coordinating the wire plants of the power and telephone companies led to the formation of the Joint General Committee of the National Electric Light Association and Bell Telephone System in 1921. Since that time an extensive program of investigation has been in progress and many important results of this work were published in 1930 as Volume 1 of Engineering Reports of the Joint Subcommittee on Development and Research. A review of the work of this subcommittee was given in a group of four papers presented at the 1931 Winter Convention as a symposium on the coordination of power and telephone plants.

During the last two or three years three other Joint General Committees have been organized with the general objective of working out methods of procedure for the coordination of wire plants. These are the Joint General Committee of the Western Union Telegraph Company and the National Electrical Light Association, the Joint General Committee of the American Railway Association and National Electric Light Association and the Joint General Committee of the American Railway Association and the Bell Telephone System. These committees are proceeding with the formation of the fundamental bases of procedure for the cooperative handling of mutual problems between the utilities concerned and the carrying out of such development and research work as appears to be necessary in connection with the problems involved.

Applications of Probability Theory in Telephone Practise

The importance of the probability theory and the related theory of statistics in telephone practise are, in a general way, well known by the engineering profession. However, a short résumé of the matter together with a brief statement of additional applications made during the last year may be welcome.

The oldest and best known application of the theory in the art of communication is its use in the determination of the loads which can be placed on various manual and dial trunking arrangements in order that efficient service be rendered. Unbalance effects on loaded circuits and other transmission lines of periodic structure also give rise to linear and other types of error function problems for the solution of which recourse to probability theory must be had.

The scheduling of adequate sampling plans for determining the quality of telephone equipment at various stages of its manufacture, after delivery to the operating companies and after installation, make heavy demands on probability and statistical theory. Within the last year extensive sampling schedules have been made for determining the extent to which the human factor in the telephone business is performing its assigned functions. For example, sampling theory is now being applied with reference to the performance of the repair clerk and test desk man, the quality of work done by installers and repairmen, the quality of subscribers' contacts in commercial offices and the quality of directory printing and delivery service.

Electric Welding

ANNUAL REPORT OF THE COMMITTEE ON ELECTRIC WELDING*

THIS report consists of two sections; the first dealing with the Organization and Policies, and the second with the Progress of the Art.

I. Organization and Policies

During its first three years, this newly created committee has gradually extended its field of action until the field overlapped that of various technical committees of the American Welding Society. It was necessary, therefore, to establish a clear understanding with the A. W. S. in order to create an exchange of information and to avoid duplication of effort. It became apparent that it would be more profitable to leave such problems as the metallurgy of the welding processes, methods of testing the completed welds and organization of the procedure control, to the committees of the A. W. S.

Our efforts have been concentrated, therefore, on sponsoring the advancement of the theory of the electric arc, the design of the electric welding apparatus and the use of electric welding processes in the manufacture of electrical machinery.

The gathering of all available information on the progress of the art and the presentation of these facts through the medium of our annual report to the whole membership of the Institute is another important function of this committee.

As the activities of our committee have increased, it was felt at the beginning of the present fiscal year that the time had come to organize several subcommittees composed of physicists and engineers especially interested in one of the above specific problems. The committee as a whole has been concerned with the general survey of the advance in the progress of the art.

The present organization of subcommittees is as follows:

Research (Phenomenon of the Electric Arc) Dr. S. Dushman, Chairman, Dr. J. Slepian, Mr. H. M. Hobart, Mr. W. Spraragen, Mr. A. M. Candy.

Electric Welding Machinery (Designs of) Prof. F. Creedy, Chairman, Mr. J. C. Lincoln, Mr. A. M. Candy, Mr. A. Churchward, Mr. H. M. Hobart, Mr. K. L. Hansen.

Resistance Welding. The subcommittee on Resistance Welding has only been partly organized with Mr. E. Lunn and Mr. H. W. Tobey gathering preliminary information.

Papers

Through the efforts of the members of our committee, a symposium on welding was presented during the Winter Convention of the Institute. A paper by Dr. G. M. Shrum and Mr. H. G. Wiest, Jr. was presented by Dr. S. Dushman which related to the new experiments of the phenomenon of the electric arc.

Three papers were presented by Mr. J. H. Blankenbuehler, Mr. S. R. Bergman and Professor F. Creedy on the subject of the design of electric welding generators.

Two papers by Mr. M. Thomson and Mr. S. Martin, Jr. were on the subject of the resistance welding as applied in the manufacture of electrical apparatus.

Another paper on the design of the electric welding generator was published in the JOURNAL of the A. I. E. E. prior to the above Convention, by Mr. C. J. Holslag.

II. Progress of the Art

General

The past year was characterized, first, by an outstanding improvement in the quality of the welds produced by various methods, secondly, by the refinement in the design of electric welding equipment, and thirdly, by the unprecedented expansion in the use of the resistance welding process.

The methods of testing and the procedure control attained such refinements that the quality of the welds produced on pressure vessels can be checked with accuracy.

The most outstanding accomplishment in the field of application of the electric arc in the past year, is the fabrication of 24 all-welded steam boilers by the Babcock & Wilcox Company for the United States Navy for installation on the new scout cruisers.

In the past, the arc welded oil stills for high pressure were manufactured successfully for a number of years by the A. O. Smith Corp., yet it is the first time that high-pressure steam boilers were fabricated by the electric arc and installed on the fighting ships.

Improvement in the Quality of Arc Welds

Arc welding was introduced into general use in this country during the World war. The first attempts to adopt the European method of welding with heavily fluxed electrodes, did not meet with general approval. Instead, the technique of welding with bare wire electrodes was developed to such an extent that practically

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all the arc welding in this country was done, until recently, by that method.

Since the tensile strength of the welds produced with such electrodes is about the same as that made by the most expensive heavily fluxed electrodes of European make, for many applications the bare wire is entirely satisfactory. It should be noted, however, that both bare wire electrodes and heavily fluxed electrodes of European make produced welds lacking in ductility.

With the extension of the field of application of arc welding, it soon became apparent that for the use of arc welding on such structures as pressure vessels, electrodes of different types would be needed. Over ten years ago, work in this direction was started by the Electric Arc Cutting & Welding Co., Wilson Welder & Metals Co., and some other concerns and individual investigators, each of whom produced a new type of heavy or lightly covered electrode. These electrodes had certain advantages over the bare wire electrodes.

Decided advance in the improvement of the quality of the welds was made a few years ago by the General Electric Co. with the hydrogen gas shielding of the weld, by A. O. Smith Corp. with special wood pulp covered electrodes, and by several other individual investigators and concerns, each of whom developed in the last year or two, a very efficient type of fluxed electrode giving welds of high ductility, a quality which is absolutely essential for work on steam boilers and many other types of pressure vessels.

At the present time, several manufacturers of pressure vessels, in advertising their welds guarantee a ductility unheard of only a few years ago. The General Electric Co., A. O. Smith Corp., Blaw-Knox Co., Struthers-Wells Co., Kellog Company, Fusion Welding Corp., The Lincoln Electric Co., and Babcock & Wilcox Co. are probably only a part of the list of concerns now producing highly ductile welds. This advance in the quality of the produced welds opened new fields for arc welding, of which the steam boilers for the United States Navy is an outstanding example.

Resistance Welding

The welds produced by this process are of the highest quality with respect to strength, ductility and resistance to fatigue. The development, therefore, consisted mostly in the improvements in the design of the welding machines and application of such machines in new fields.

The most outstanding feature of the past year was the great development of welding pipes by the resistance process. Several machines up to 6,500 kva. each have been built for welding, by the flash welded process, longitudinal seams 40 ft. long. By the use of such machines, a weld 40 ft. long is produced simultaneously all along the seam and in less than one minute on pipe some 24 inches in diameter and of a plate up to ½ inch in thickness. Similar resistance welding machines of 1,200-kva. capacity weld circumferential seams of similar pipe. All the electrical parts for the above machines have been built by the Swift Electric Welder Company. A spot welder of 800 kva. with electrodes of 3½ inches in diameter, which probably is the largest machine ever built in this country, has been successfully built by the same Company for special heavy welding work.

Other concerns (amongst which the Thomson-Gibb Electric Welding Co. is the pioneer), developed the continuous method of seam welding. This last method had previously been used on a large scale for welding thin walled tubing. Within the last year, this method has been applied to the continuous seam welding of pipe of considerable diameter and wall thickness. At the present time, several manufacturing concerns are producing welded pipe up to 40 ft. long and it is expected that by butt welding two of such lengths in the factory, a pipe of 80 ft. long will be available for construction work.

This great development in the welding of industrial pipe by the resistance process was due to the decision of several large concerns to extend the pipe lines for transportation of natural gas and gasoline from the producing areas to the consuming districts over 1,000 miles away.

This development should be of especial interest to engineers since it indicates the possibility of transmission of power over longer distances by gas than have been accomplished by the electric current.

As was remarked by a well-known consulting engineer, the electrical engineer should rise to the occasion and surpass gas with respect to distance and amount of power transmitted. He has plenty of as yet undeveloped alternatives to the 60-cycle synchronous system as at present employed.

The resistance welding process is being further developed in the application to the automobile industry where it greatly outdistances all the other welding processes. Another important field of application of resistance welding is the manufacture of wire goods which comprises even such fields as the welding of wire netting for reinforced concrete. Machines making up to 24 welds simultaneously have been built and are in successful use. In the fabrication of electrical machinery, the resistance process has already been applied on a large scale to the manufacture of small transformer tanks. The application of this process has also extended to the fabrication of motor magnet frames.

Structural Steel Welding

In the field of structural steel, arc welding has already proved to be entirely satisfactory, and therefore, received further important applications. All arc welding of this type of construction is done with entire satisfaction with the bare wire electrodes.

Amongst the high buildings erected during the past year, (partly by welding and partly by riveting) are the buildings of the Southern California Edison Co., the Edison Electric & Illuminating Co. of Boston, and

the DuPont Corporation at Wilmington, Delaware. The highest building entirely welded was erected by the Dallas Power & Light Co. This building has 19 stories and measures 246 feet above the foundations. The Westinghouse company erected several industrial and office buildings, all entirely welded. The highest of these buildings measures 190 feet above the foundations. It should be noted that in the erection of the buildings, only very few welding machines are necessary. In the erection of the 19 story building at Dallas, only four arc welding machines were used.

Shipbuilding

In the shipbuilding field, arc welding is being extended rapidly and all our shipbuilding companies such as the Newport News Shipbuilding & Drydock Co., The Bethlehem Shipbuilding Co., and many others as well as the U. S. Navy Yards, are using arc welding quite extensively for fabricating various internal structures on ships. On smaller ships, the electric arc has been used successfully even in welding the hulls.

The Electric Boat Company, at Croton, launched during the past year, an all welded barge, 118 ft. long, of Ewertz patented design. The Federal Shipbuilding & Drydock Co., at Curney, N. J., welded a number of barges, and the Standard Steel Shipbuilding Corp., of Los Angeles, completed an all-welded 65-ft. yacht.

The application of arc welding in shipbuilding requires a careful study of the design of the welds and the details of the technique of welding. The long welded seams characteristic in this type of construction may be subject to high internal stresses and therefore should be produced by the best known methods and electrodes. The amount of welding per ton of steel in shipbuilding is very much greater than in the erection of buildings where only the short welds are necessary. It may be expected that in the construction of barges and small vessels for internal navigation, arc welding will soon outdistance riveting.

Automatic Machines, Alloy Electrodes and Special Arc Torches

The design of automatic arc welding machines advanced still further and several concerns are now manufacturing either full automatic or semi-automatic machines of a very efficient design for use with metallic electrodes. The Lincoln Company made further improvements in automatic carbon arc welding machines which produce welds of high ductility, and the General Electric Company applied the atomic hydrogen process to automatic welding as well as for hand welding.

The development of special alloy electrodes for hand welding as illustrated by the Stoody process, made considerable progress. The surfacing of various parts of machines subject to wear and abrasion with hard surfaces in certain cases can be successfully accomplished.

The development of special torches for use of indirect arc (similar to the flaming arc) extended the field of arc welding to the low-melting-point alloys. A special torch developed by Hansen and utilizing the d-c. arc can now be used for brazing, soldering, and welding low-melting-point extruded alloys. Another torch utilizing the a-c. arc has also been put on the market by the Warner Co., of Los Angeles. It can be used successfully on light work of brazing, soldering, and welding steel sheets of light gage.

Design of Electric Arc Welding Generators

The advances and refinements in the design of the electric welding generators have been carefully followed by the subcommittee on Electric Welding Machinery, which reports as follows:

An outstanding feature of the year's work in the development of direct-current arc welding generators, is the attention which has been devoted to their transient characteristics. It has been realized that the momentary shortening of the arc produces a large momentary transient current, which tends to cause explosions or "sputterings" detrimental to welding. Means have, therefore, been sought by several workers by which these momentary transient currents may be eliminated and papers on the subject have been presented by Blankenbuehler, Bergman, Holslag and Creedy.

The direct-current welding generators contain a main exciting coil either shunt, separately excited, or a combination of the two, and a demagnetizing series circuit whose function is to reduce the voltage with increasing current. One important type of transient is caused by the voltage induced in the main exciting circuit by transformer action from the series demagnetizing circuit and this type of transient may be eliminated by reducing this voltage to a small value. There is no need to eliminate this voltage altogether because it is only necessary to reduce it to such a degree that the solutions of the differential equations which determine the current approximate to the logarithmic instead of the oscillatory type. Blankenbuehler discussed a machine with separately exciting coil and reverse series winding only, and injects into the separately excited circuit a voltage proportional to the current flowing through the reverse series winding (the welding current) by means of a series transformer. This voltage is opposite in direction to that induced in the same coil by the reverse series winding so that the two tend to cancel.

The machine treated by Bergman has two distinct poles whose flux cuts the conductors between positive and negative brushes. One has constant flux and the other is shunt excited from a third brush intermediate between the main brushes, armature reaction being relied upon to reduce its voltage with increasing current. In this case a series transformer is used to inject into this shunt circuit a voltage proportional to, but opposite in direction to that due to induction from the armature.

In Creedy's machine in which the effect of shunt and

separately excited windings is produced by a single coil, no transformer is employed but the same result is produced by reducing the reluctance of the main magnetic circuit so that the number of turns on the main exciting coil is very much reduced and consequently the e. m. f. induced in it by the series demagnetizing circuit becomes small. With this latter device a neutralizing winding becomes necessary to avoid sparking and excessive reactance of the armature winding.

Testing of Welds

Several non-destructive methods of testing of welds have been developed among which the X-ray method is already being applied as a regular procedure control on welds made on important structures. The magnetic and the stethoscope methods are also available. It should be noted also that a series of experiments has been conducted with the gamma rays produced by radium emanation for testing of welds on heavy plates and steel castings.

Further Research

Since the electric arc is the foundation on which the entire arc welding industry has been built, our subcommittee on Research recommends further study of this phenomenon. The outlined problems are as follows:

1. Probe measurements in arcs between iron electrodes, using a technique somewhat similar to that adopted by Nottingham in his investigations on the arc between copper electrodes in air.

2. Arc characteristics should be taken as a function of the pressure for different gases, such as carbon dioxide, air, and argon.

3. The question of the part played by fluxes, or additions of various "dopes" to the welding rod.

4. Determinations of the energy consumption at the electrodes, using a calorimetric method.

5. Accurate determination of cathode drop and its variations under varying conditions. This is an important factor in all theories of the electric arc and more accurate information on this point is certainly desirable.

6. Accurate determination of anode drop under varying conditions.

7. Study of small current arcs and particularly the glow to arc transition.

8. Mathematical study of some of the newer ideas on stability of discharges as developed by Barkhausen and others.

9. Cathode-ray study of stability of arcs such as used in electric welding. The spontaneous variations in current and voltage which are always taking place will probably be frequently beyond the capacity of the ordinary oscillograph. The influence of high frequency characteristics of the external circuit could be studied in this connection.

10. Stability of arc in magnetic field. Since arcs used in welding usually have quite strong magnetic fields, the influence of this factor in the stability of an arc is quite important.

11. Study of influence of nature of cathode surface on stability.

12. Study of influence of nature of anode surface on stability.

13. Study of passage of the deposited metal from the electrode to the work. Although a large part of the metal is deposited by liquid drops, it may be that a considerable portion passes in the form of vapor.

14. Study of the influence of superimposed alternating current of moderate and high frequency. The use of high frequency has been proposed for actual welding, but the influence upon the arc has not been studied in much detail.

It has also been suggested that the carbon welding arc be further studied, especially with respect to the blast of carbon vapor from the cathode spot.

University Activities

Through the initiative of the American Bureau of Welding, twelve engineering colleges and universities have become interested in various problems relating to welding. In addition to the research work conducted by professors, the students in several colleges write their theses on welding in preparation for the degree of B. S. or M. S.

It should be noted that welding, and especially electric welding, is receiving considerable attention in various universities abroad. Germany is probably leading in that respect because electric welding is considered to be of such importance that some colleges in that country confer the degree of Doctor of Engineering for any adequate research work on problems of welding.

In the Soviet Union, welding has received during the past year, an unprecedented expansion. To deal more adequately with the problem of a highly trained personnel, a special Welding Institute is being organized which will cost over $1,500,000, to train future welding engineers.

Electrical Machinery

ANNUAL REPORT OF COMMITTEE ON ELECTRICAL MACHINERY*

I. Organization and Activities

THE committee is organized with five permanent subcommittees, and its work has consisted of the review of papers, arrangement of programs for technical sessions, and the preparation of Standards and Test Codes.

Forty papers on electrical machinery were presented during the calendar year 1930. Others could have been made available if facilities for presentation and publication had permitted. The committee believes that the preparation of short and informal papers designed to bring out discussion at conventions should be encouraged, and that highly technical papers whose chief value is for reference should be presented before small groups in parallel sessions.

Standards

The Subcommittee on Transformers has been very active and during 1930 prepared "Recommendations for the Operation of Transformers" and brought to conclusion a revision of the A. I. E. E. Standards for Transformers.

The Subcommittee on Synchronous Machines, besides completing A. I. E. E. Standards for Capacitors, has initiated a number of revisions for the A. I. E. E. Standards for Synchronous Machines.

The Subcommittee on Mercury-Arc Rectifiers is working in close cooperation with the Sectional Committee on Rectifiers, which has under preparation Standards for Mercury-Arc Rectifiers.

Test Codes

Preliminary drafts of test codes for transformers, induction motors, direct-current machines and synchronous machines have been prepared. These codes are intended to provide definite instructions for the more generally applicable field and factory methods of conducting and reporting acceptance and other tests of general commercial value.

†Legend for Manufacturer Designation:

In order to conserve space and avoid numerous repetitions of the names of manufacturers, the following designation has been used throughout the report:

AC—Allis-Chalmers Manufacturing Co.
BB—American Brown Boveri Co.
CGE—Canadian General Electric Company
CW—Canadian Westinghouse Co., Ltd.
EM—Electric Machinery Mfg. Co.
GE—General Electric Co.
W—Westinghouse Electric & Mfg. Co.

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II. Resumé of Progress of the Art

SYNCHRONOUS MACHINES

Steam-Turbine Driven Alternators

The size of the single-shaft units has again been increased, two 200,000-kva., 0.8 power-factor, 1,800-r. p. m., single-shaft, tandem-compound, turbine-generator units (GE)† now being built for the Hudson Avenue Station of the Brooklyn Edison Company. They have double windings rated at 16.5 kv., and double-winding auto-transformers will step up the voltage to 27.6 kv.

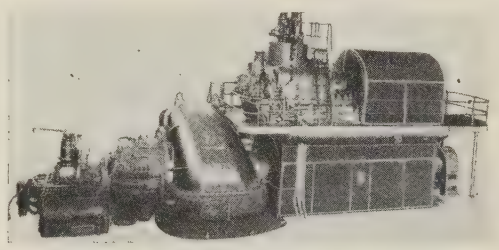

FIG. 1—50,000-KW., 3,600/1,800-REV. PER MIN., VERTICAL-COMPOUND, TURBINE-GENERATOR UNIT (GE)—PACIFIC GAS & ELECTRIC CO.

A 110,000-kw., 1,200-lb., vertical-compound, double-winding turbine-generator unit (GE), with duplicate generators on the high- and low-pressure turbines, has been constructed for the Ford Motor Company.

A 50,000-kw., 3,600/1,800-r. p. m., 1,200-lb. unit, in which the high- and low-pressure elements were combined to form a vertical-compound turbine-generator set (GE) was constructed for the Pacific Gas & Electric Company and a duplicate unit is nearing completion. (Fig. 1.)

Three 18,750 kva., 3,600-r. p. m., turbine-generator units (W), the largest machines of this speed yet manufactured in this country, were put in operation at Baton Rouge by the Louisiana Steam Products Company. An outstanding feature of these machines is the internal propeller fan used, the success of which has created a new interest in internal fans for large machines.

High-voltage turbine generators rated 121,000 kva., 18 kv.; 147,000 kva., 22 kv.; and 94,000 kva., 22 kv. are now in the first stages of construction (AC).

The satisfactory completion of tests on a 9,375 kva.

hydrogen cooled, turbine generator (W) (Fig. 2) have encouraged the serious consideration of hydrogen cooled turbine generators for ratings above 30,000 kva.

Waterwheel-Driven Alternators

The year 1930 has been notable for the number of large hydro-electric developments which have either been contemplated or put into operation. Table I is a list of some of the more interesting hydraulic-driven generators installed or under construction during the past year.

The 77,500-kva. generators (GE) for the Dnieper River Development in Russia, operating under a hydraulic head of 123 feet are the largest waterwheel generators yet constructed. (Fig. 5.) The total weight of each generator will be approximately 880 tons, the weight of the rotor and shaft will approach 445 tons, and the shaft itself, which is 36 ft. long and 40 in. in diameter, with a 70-in. flange on each end, will weigh about 68 tons. The stator is fabricated in six sections with punchings and windings assembled in each section before shipment.

TABLE I—WATERWHEEL-DRIVEN ALTERNATORS

Purchaser—Location	No.	Kva.	R. p. m.	Type	Fig.	Mfr.
Amtorg Trading Co	4*	77,500	88.25	Vert	4	GE
Dnieper River (Russia)	1	77,500	88.25	Vert		GE
City of Seattle						
Skagit River	2	66,700	171.5	Umbrella		W
Inland Power & Light Co	1	56,250	120	Overhung		GE
Ariel Development						
Alcoa Power Co	4	50,000	120	Vert		CW
Chute-à-Caron						
New York Power & Light Corp	1*	47,000	81.8	Overhung		GE
Spier Falls						
Beauharnois Power & Light Co.						
St. Lawrence River	2	46,625	75	Umbrella		CGE
St. Lawrence River	2	43,883	75	Umbrella		CGE
Western Power Co. of Can. Ltd	1	44,000	120	Umbrella		CW
Ruskin Generating Station B. C.						
Lexington Water Power Co.						
Saluda Development	4*	40,625	138.5	Umbrella	3	W
New England Power Construction Co.						
Fifteen Mile Falls	4*	39,000	138.5	Umbrella		W
Shawinigan Engineering Co	4	36,000	109.1	Vert		CW
Rapid Blanc Development						
Pennsylvania Water & Power Co.						
Safe Harbor, Susquehanna River	4	31,111	109	Overhung		GE
	2	31,111	109	Umbrella		W
New Kanawha Power Co.						
New Kanawha River	4	30,000	150	Vert		W
Pacific Gas & Electric Co.						
Tiger Creek	2	30,000	225	Horiz		W
Gatineau Power Co	1	28,500	125	Vert		CW
Paugan Falls P. Q.						
James MacLaren Co	4	28,000	166.7	Vert		CW
Masson Power Development						
Shawinigan Water & Power Co	1	25,000	112.5	Vert		CW
Grand Mere, P. Q.						
Toccoa Electric Power Co.						
Blue Ridge	1	25,000	164	Umbrella		W
Montana Power Co.						
Morony	2*	25,000	81.8	Umbrella		W
Hydro Electrica Espanola	2	25,000	375	Vert		GE
Spain						
Union Electric Lt. & Pr. Co	6	23,888	112.5	Umbrella		W
Osage River						
Chats Falls Executive Board	8	23,500	125	Vert		CW
San Joaquin Light & Power Co.						
Merced Falls	1	4,000	128	Vert	4	W

*Included in report of last year.

The 31,111-kva., 109-r. p. m., umbrella-type generators (GE and W) for the Safe Harbor Development of the Pennsylvania Water & Power Company are to be driven by Kaplan-type turbines, and will operate as motors in a reversed direction to pump water back into the fore-bay for use during the peak-load periods.

High Frequency Generator

A 500-kva., 960-cycle generator (W) built for the American Brass Company will supply power for an

FIG. 2—9,375 KVA., HYDROGEN-COOLED, TURBINE-GENERATOR (W)

electric furnace. The rotor required special construction to retain the field coils in place at the high peripheral speed of 20,000 ft. per minute.

A 666-kva., 960-cycle single-phase generator (GE) was placed in operation at Watertown (Mass.) Arsenal in November, 1930, and a 750-kva., 960-cycle, three-phase generator (GE) is being built for the American Brass Company.

FIG. 3—FOUR 40,625-KVA., 138.5-REV. PER MIN., UMBRELLA-TYPE, WATERWHEEL-GENERATOR UNITS (W)—SALUDA DEVELOPMENT, LEXINGTON WATER POWER CO.

Synchronous Condensers

A 50,000-kva., 13.2-kv., 600-r. p. m., 50-cycle hydrogen-cooled condenser (GE), equal in capacity to the largest air-cooled machines, has been constructed for the Southern California Edison Company. (Fig. 6.) The total capacity of hydrogen-cooled condensers now in service is 137,500 kva. with 70,000 kva. additional on order.

Two 15,000-kva., outdoor hydrogen-cooled condensers (W) have been constructed; one rated at 50 cycles, 750 r. p. m. for the Southern California Edison Company, and the other rated at 60 cycles, 720 r. p. m. for the Indiana & Michigan Electric Company.

A 7,500-kva., 6.6-kv., 900-r. p. m., 60-cycle air-cooled, outdoor condenser (AC) has been constructed for the Central Illinois Public Service Company. (Fig. 7.)

Industrial Synchronous Motors

The application of synchronous motors to industrial purposes is being extended as the knowledge of the starting, acceleration, and pull-in requirements is increased and as the prediction of these characteristics becomes more exact. A number of unique designs has been developed during the year.

A 500-hp., 72-r. p. m., vertical-shaft motor (GE) has been applied to a Fuller Lehigh coal pulverizer, in which the motor frame forms the base on which the pulverizer is built. The motor develops considerably more than normal torque from start to pull-in in order to obtain successful starting with a choked mill. Over-

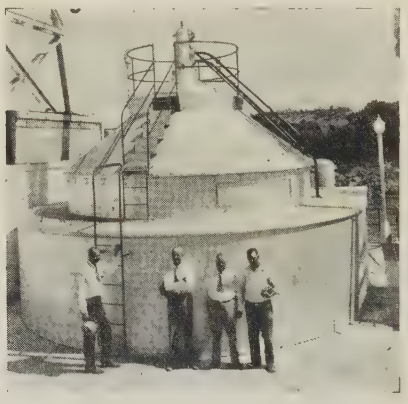

FIG. 4—4,000-KVA., 128-REV. PER MIN., VERTICAL-TYPE, OUTDOOR, WATERWHEEL GENERATOR (W)—MERCED FALLS, SAN JOAQUIN LIGHT & POWER CO.

voltage for starting is supplied by a step-up auto-transformer.

A 700/350-hp., 2.3-kv., 277/138-r. p. m., three-phase, 60-cycle, two-speed synchronous motor (W) has been applied to a vertical centrifugal pump for the Ford Motor Company.

A new method for securing reduced starting kva. has been introduced, which utilizes the inherent reactance of the motor itself, a 3,000-hp. (GE), five 3,500-hp. (EM) and several smaller motors having been built. The stator is wound with two or more parallel circuits so arranged within the core as to obtain increased reactance when only one of the circuits is energized. The starting characteristics obtained are somewhat similar to those secured by using external reactors in series with the lines.

A 600-hp., 440-volt, 300-r. p. m., three-phase, 60-cycle, synchronous motor (EM) was applied for the first time for continuous reversing duty on a copper

rolling mill, synchronous motors having been generally considered unsuitable for constant reversing duty on account of their inferior starting characteristics. The operating requirement that the mill be reversed from full speed forward to full speed reverse in five seconds necessitated special design of the stator and rotor to

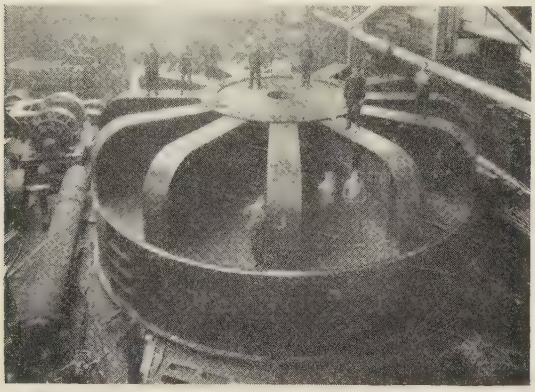

Fig. 5—77,500-Kva., 88.25-Rev. per Min., Vertical-Type, Waterwheel Generator (GE)—Dnieper River Development (Russia) Amtorg Trading Company

dissipate heating, which was accomplished by the use of ventilating spacers in the armature core and field poles and by special cage end-ring construction. (Fig. 8.) Three parallel circuits were used in the stator, which were switched successively both for forward and reverse acceleration in order to reduce the increment starting kva. demand.

A slow-speed, vertical-shaft motor (EM) has been incorporated in a pulp hydrator base. The motor was

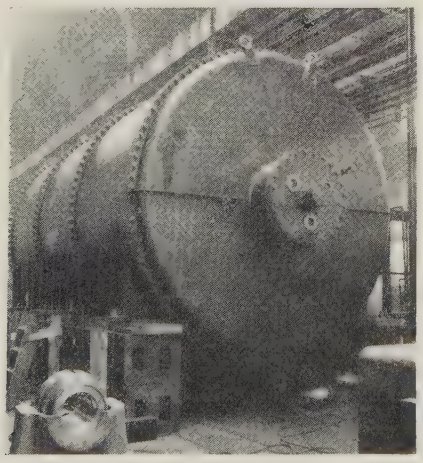

Fig. 6—50,000-Kva., 13.2-Kv., 600-Rev. per Min. 50-Cycle, Hydrogen-Cooled Synchronous Condenser (GE)—Southern California Edison Co.

provided with a thrust bearing which carries the weight of the rotor and hydrator rotating member. To permit adjustment of the clearance between the rotating and stationary members of the hydrator, the motor was provided with a micrometer raising and lowering device, the field poles being slightly longer than normal to permit a moderate movement of the rotor axially with respect to the stator.

Marine Synchronous Motors

Several electric-propelled vessels of interesting design were placed in service or are under consideration.

TABLE II—MARINE SYNCHRONOUS MOTORS

Vessel (or purchaser)	No.	Hp.	R. p. m.	Mfr.
S. S. Santa Clara	†2	6,300	120	GE
S. S. Morro Castle	†2	8,000	143	GE
S. S. Oriente	†2	8,000	143	GE
S. S. President Hoover*	†2	13,250	133	GE
S. S. President Coolidge	†2	13,250	133	W
United Mail S. S. Company (6 vessels)‡	12	5,500	125	GE

*Launched December 1930, Transoceanic service 1931.
†Included in report of last year.
‡Under construction

The 13,250-hp., 133-r. p. m. ship-propulsion motors (GE, W) are the largest marine synchronous motors yet built. These motors are completely fabricated.

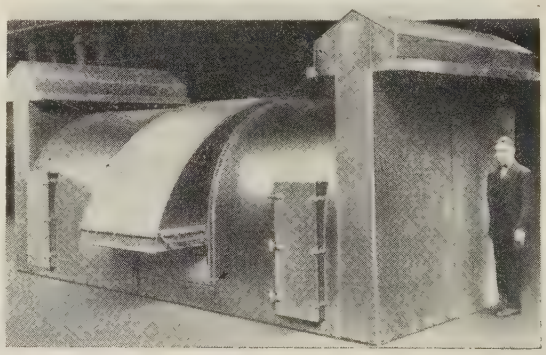

Fig. 7—7,500-Kva., 6.6-Kv., 900-Rev. per Min. 60-Cycle, Air-Cooled, Outdoor, Synchronous Condenser (AC)—Central Illinois Light Co.

Frequency Converters

There is a growing tendency to install large machines outdoors in order to reduce building costs. The first frequency-converter units to be so installed have been built during 1930 and will be placed in operation during 1931.

Two such units, the generators being rated at 21,000 kva., 0.7 power factor, 300 r. p. m., 25 cycle, one-phase, and the motors at 18,000 kva., 0.9 power factor, 300 r. p. m., 60 cycle, three-phase (W) will be installed at the Wayne Junction Substation of the Philadelphia Electric Company to supply power for the new Reading Railroad Electrification (Fig. 9). Conventional indoor design was followed, with spring mountings to absorb the single-phase torque pulsations, the machine being adapted for outdoor service by enclosing in a sectionalized sheet steel housing approximately 64 ft. long by 25 ft. wide.

Induction Machines

A major activity of the manufacturers during the year has been the development of new lines of induction

motors to conform with the frame sizes and mounting dimensions standardized by the National Electrical Manufacturers Association as announced in last year's report. In many cases this program has included a change in electrical design to improve the noise and torque characteristics. Much attention has also been given to the appearance in order to meet the ever more exacting aesthetic tastes of the public.

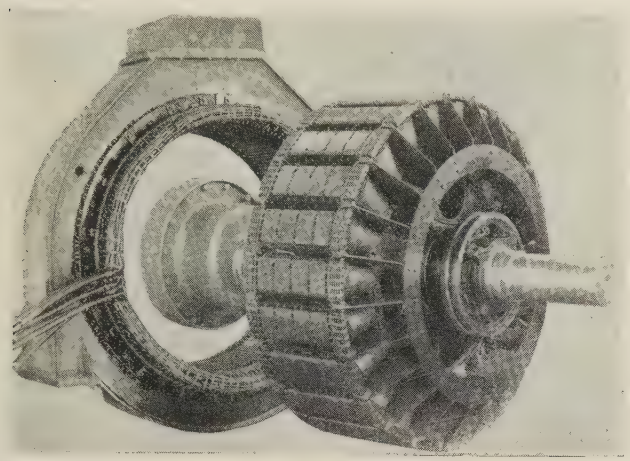

Fig. 8—600-Hp., 440-Volt, 300-Rev. per Min. 60-Cycle, Continuous-Reversing-Duty, Synchronous Motor (EM)—Copper Rolling Mill

Several manufacturers now furnish lines of motors in integral up to 100 hp. as well as fractional horsepower sizes for class I and class II hazardous locations (inflammable gases and combustible dust) as defined in the National Electrical Code.

Complete lines of totally-enclosed, fan-cooled continuous duty 55-deg. cent. motors as large as 250 hp., particularly suited for use in harmful dust conditions, have now been developed by many manufacturers and the use of this type is steadily growing.

An extensive application of a novel induction motor (GE) has been made to conveyor tables in steel mills. (Fig. 10.) The conveyor roller is a hollow cylinder mounted on ball or roller bearings rotating around a stationary supporting shaft on which the stator is mounted. The cylindrical convey roll, which surrounds the stator, serves as a secondary, the induced currents flowing in the solid steel inner surface of the roll.

D-C. Machines

Motors and Generators

An 8,000-hp., 800-volt, 40- to 100-r. p. m., motor, having a peak capacity of 22,000-hp., 2,900,000-lb. ft. torque, has been built (GE) for a blooming mill of the Illinois Steel Company. This is the largest single-armature motor employing fabricated construction for the major parts.

Two 5,000-hp., 40-r. p. m., double-armature motors were built (W) for operating the main rolls of the new 10,000-hp. blooming mills at the South Chicago Plant of the U. S. Steel Corporation, which is the most powerful mill yet built. Each of the two main rolls is driven by one of the motors, the two being kept at the same speed by electrical control instead of being geared together as in former installations. Each double motor has a peak-torque capacity of two million lb. ft. Power is supplied from three 3,000-kw. induction motor-generator sets. The series fields of the three generators are interconnected in such a way that parallel operation is secured with satisfactory division of load.

Planer motors up to 75 hp. rating with speed ranges by field control of 6 to 1 have been developed (GE and W), and further increases in size of this class of motor are under consideration.

A 50-hp., 1,600-r. p. m., 75-deg. cent. one-hour motor has been developed (W) for application on a coal cutter to meet a limiting over-all height of 12 in.

Six 3,500-hp., 330-r. p. m,, motors have been constructed (AC) for a 96-in. plate mill of the Illinois Steel Company. Power is supplied by two 6,000-kw. synchronous motor-generator sets.

Two motor-generator sets, consisting of two 3,000-kw., 600-volt, compensated generators driven by one 6,500-kva. synchronous motor, have been constructed (GE). These sets will deliver 6,000 kw. continuously with 9,000 kw. for two hours or 7,500 kw. continuously without overload.

Exciters

Further developments in "rapid response" exciters have occurred during the year, with the objects of securing higher efficiency and improved control. The use of a special Wheatstone Bridge type of rheostat (GE) enables the exciter to operate down to zero or even reversed voltage.

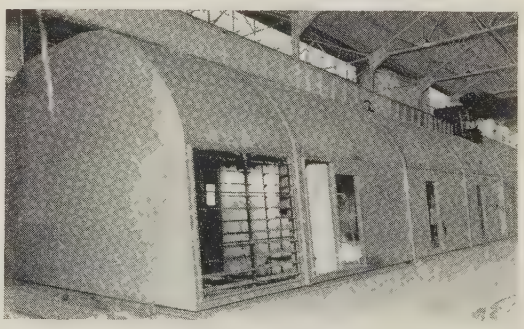

Fig. 9—21,000/(18,000)-Kva., 300-Rev. per Min.. 25-(60)-Cycle, One (Three) Phase, Frequency-Converter Outdoor Housing (W)—Wayne Junction Substation, Philadelphia Electric Co.

A 90-kw., 3,600-r. p. m., direct-connected, turbine-generator exciter has been developed (W) which is one of the largest exciters ever built for this speed. (Fig. 11.)

Synchronous Converters

Four 5,440-kw., 167-r. p. m., 16,000-ampere, 25-cycle, synchronous converters were constructed (2 GE and 2 W) for a chemical plant in the Niagara Falls District. The converters are enclosed in volute housings, and the

outgoing air is discharged outside the building. Direct-current voltage adjustment is obtained by means of tap-changing equipment on the supply transformers. A novel feature of construction used on two of these machines (GE) is a "tandem" commutator, which consists of two sets of shorter copper segments, together with insulation and clamping rings, mounted on a common support so arranged that air can pass between the adjacent ends of the two commutators where their segments are connected together. This construction (Fig. 12) results in lower temperature rise and smaller expansion strains and, consequently, a smoother running surface than is usually obtained with an equivalent single-unit commutator.

Transformers

Power Transformers

Extensive theoretical and experimental study of transient voltage phenomena was continued during the year, and the development of means for protection against lightning surges advanced rapidly. One indication of the progress made during the year is given by the successful outcome of full voltage flashover tests on a large transformer.

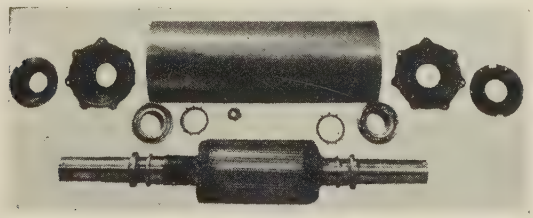

Fig. 10—40-Lb.-Ft., 250-Volt, 125-Rev. per Min., 25-Cycle, Conveyor-Roller Induction Motor (GE)

A 13,000-kva., 230-kv., wye-grounded, non-resonating transformer built for commercial use (GE) was subjected to a series of artificial lightning voltage tests. The transformer was connected to a lightning generator by a short transmission line insulated with fourteen 10-in. units, spaced 5¾ in. in suspension, which is used quite generally for 230-kv. service. The insulator strings were repeatedly flashed over without apparent damage to the transformer. The line insulation was then increased until the transformer bushings were flashed over. The transformer was subjected to repeated waves both above and below the bushing flash-over voltage, after which it withstood all A. I. E. E. standard tests.

A study of transient voltage phenomena within auto-transformer windings resulted in the development of the non-resonating auto-transformer (GE), of which several have now been built for 230-kv. service.

Through the development of the grounding neutral impedor (GE), the use of the non-resonating transformer was extended to include banks with neutrals isolated or grounded through resistance or reactance.

Investigation (W) has shown that a comparatively high resistance can be used in the neutral of a bank of power transformers and the bank will perform practically the same as though it were solidly grounded. The same result can be obtained with reactance in the neutral paralleled by a protective device, such as a lightning arrester. The internal voltages at points within the winding have been found to be practically identical for a bank with a solidly grounded neutral and for one with a reactance paralleled by a lightning arrester.

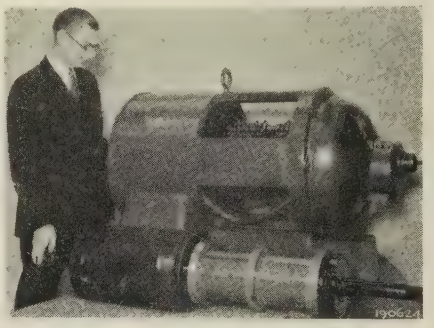

Fig. 11—90-Kw., 3,600 Rev. per Min., Direct-Connected, Turbine-Generator Exciter (W)

In order to extend the benefits of load-ratio control to small transformers, a lighter type of equipment has been developed for 15-kv. service (GE). This consists of a multi-point switch which permits the load current to leave each tap point over two paths; *i. e.*, over two switch arms which connect to the bridging reactor. A typical application of this equipment is represented by a 3,333-kva., 69.7/115 Y-13.8-kv., one-phase transformer, in which thirteen operating positions are provided by the installation of the control device in the low-voltage winding. In this type of construction all moving parts, that is, the ratio adjuster and two contactors, are mounted outside the main transformer tank.

Fig. 12—5,440-Kw., 340/270-Volt, 16,000-Ampere, 25-Cycle, Shunt-Wound, Synchronous Converter with Tandem Commutator and Brushes (GE)

Several 5,000-kva., 13.2-kv., three-phase, furnace transformers, with a new type of tap-changing equipment, have been built (W) for the Ford Motor Company. These transformers deliver a normal low-voltage current of 12,800 amperes at 225 volts, with a maximum current

of 19,200 amperes at 150 volts. A special motor-operated tap changer provides six different delta low voltages and a change from delta to star on the high-voltage winding gives six additional delta low voltages. Two individual tap changers are operated by one motor and all the voltages and connections are obtained by the operation of a single control switch at the switchboard.

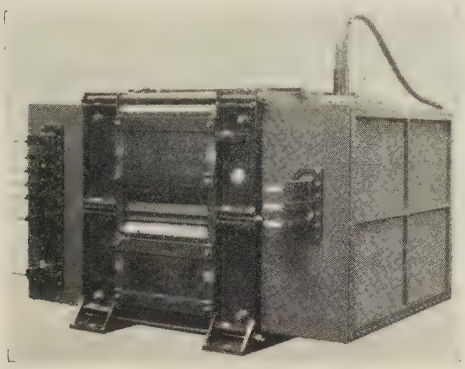

Fig. 13—4,200 Kva., 11,000,-915-46 Volts, 25-Cycle, Air-Blast, Locomotive Transformer (GE) (W)—Pennsylvania R. R.

A 4,200-kva., 11,000-915-46-volt, air-blast transformer of special construction was built (coordinated design of GE and W) for installation in a locomotive where space is at a premium. (Fig. 13.) It was, accordingly, designed for minimum dimensions and weights, the floor space occupied being 6 ft. 8 in. by

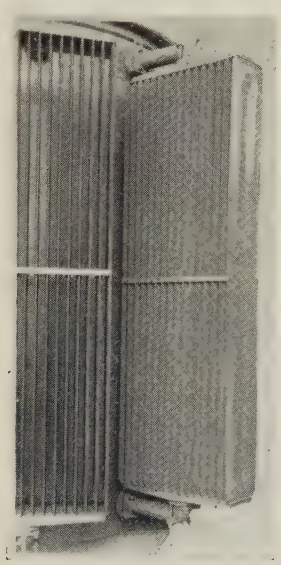

Fig. 14—Outside-Edge-Welded Transformer Radiator (W)

7 ft. 3 in. and the total weight being approximately 26,000 lb. A 2,800-kva. transformer of the same type has also been developed. These transformers are suction air-cooled and of exceptional mechanical strength, being braced and insulated for the severe operating conditions incident to locomotive service.

Power-Transformer Auxiliaries

While the method of cooling transformers by means of "banked" radiators was not used to any great extent following its development several years ago, it was extensively applied during the past year. About 200,000 kva. in transformers of this construction are in service and more than 600,000 kva. are now under construction (GE).

A new type of transformer radiator has been developed to replace the tubular type on all Westinghouse large self-cooled power transformers. (Fig. 14.) All of its joints are formed with edge welds on the outside of the radiator, and there are no crevices or flat surfaces where water can accumulate. The open construction facilitates cleaning and painting.

A 20,000-kva., 66-22-kv., load-ratio-control transformer, equipped with unusual pothead disconnecting switches has been built (W) for the State Line Generat-

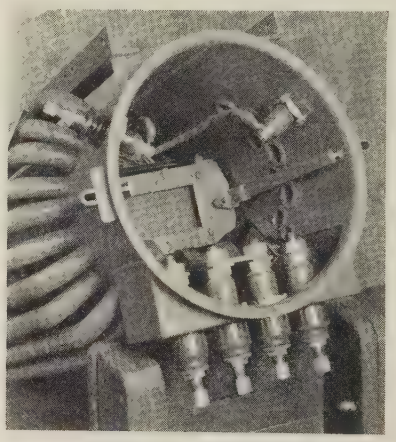

Fig. 15—100-Kva., 2,080-115/230-Volt, 60-Cycle, Distribution Transformer Equipped with Detachable Bushing (AC)—Commonwealth Edison Co.

ing Company. These high-voltage switches disconnect the transformer from the line and connect test bushings to the 66-kv. cable lines, which can then be tested with 330 kv., direct current. The pothead equipment also included oil reservoirs used to maintain pressure on the oil-filled cables to which the transformer is connected.

A new no-load ratio adjuster has been developed (BB) which is operated through the side of the tank wall instead of the cover, making it more convenient to operate and permitting the tap position to be safely checked without deenergizing the transformer. A novel form of connection is used between the internal and external parts which permits engagement or disconnection of the two parts, when the transformer core is tanked or untanked, without the necessity of crawling inside to remove pins, bolts, etc.

Distribution Transformers

A new single-bushing, single-phase transformer has been designed (GE) for 110-kv. rural service. It is arranged for connection from line to neutral on a 110-

kv. circuit, which is insulated for 132-kv. service. In order to secure a low over-all height, the interior was so constructed as to give the equivalent of an inverted winding. The bushing was then connected to the bottom of the coil stack, thereby effecting a low height in spite of the large size of the bushing and the amount of insulation required for operation on a 132-kv. insulated line.

A detachable bushing has been developed (AC) for distribution transformers, particularly for installation where lightning conditions are abnormally severe, which can be replaced without removing the case from the pole. (Fig. 15.)

Rectifiers

The installation of rectifiers has continued to increase at a rapid rate, particularly when measured in terms of the aggregate kw. capacity.

	No.	Kw.
Put into operation during 1930	33	75,225
Put into operation during 1929	30	48,125
Increase	10%	58%
Put into operation during 1930	33	75,225
Being erected during 1930	26*	71,400*
On order at end of 1930	29	79,275
Total for 1930	88*	225,900*
In service at end of 1929	90	102,309
Grand total	178*	328,209*

*In addition one spare 500-kw. rectifier tank (without transformer) was supplied.

The mercury-arc rectifiers put into operation and being erected during 1930 and on order at the end of the year are shown in Table III.

The placing in operation of fourteen units with an aggregate rating of 40,000 kw. of 3,000-volt rectifiers

TABLE III—MERCURY-ARC RECTIFIER UNITS PUT INTO OPERATION DURING 1930 OR ON ORDER DECEMBER 31, 1930

Purchaser	No. of sets	D-c. volts	Kw. per set	Total kw.	Control	Service	Put in service	Manufacturer
American Gas & Electric, New York	2	610	500	1,000	Automatic	Railway	On order	Brown-Boveri
Boston Elevated Railway	2	600	3,000	6,000	Automatic remote control	Railway	Being erected	General Electric
Chile Exploration Co	1	650	1,000	1,000	Automatic	Heavy mine haulage	1930	General Electric
Clinton, Davenport & Muscatine Railway	1*	700	500	500*	Automatic	Railway	Being erected	Brown-Boveri
Commonwealth Edison Co	2	1,500	1,500	3,000	Manual	Railway	1930	Brown-Boveri
Commonwealth Edison Co	4	625	3,000	12,000	Manual	Railway	1930	Brown-Boveri
Commonwealth Edison Co	3	625	3,000	9,000	Manual	Railway	Being erected	Brown-Boveri
Commonwealth Edison Co	3	625	3,125	9,375	Manual	Railway	Being erected	General Electric
Consolidated Mining & Smelting Co. of Canada	2	650	6,500	13,000	Manual	Electrolytic	On order	Brown-Boveri
Consolidated Mining & Smelting Co. of Canada	1	650	6,500	6,500	Manual	Electrolytic	On order	General Electric
Delaware, Lackawanna & Western R. R. Co.	12	3,000	3,000	36,000	Manual	R. R. electrif'n	1930	General Electric
Delaware, Lackawanna & Western R. R. Co.	2	3,000	2,000	4,000	Automatic remote control	R. R. electrif'n	1930	General Electric
Detroit, City of	1	600	2,000	2,000	Automatic	Railway	On order	General Electric
Edmonton, City of	1	575	1,325	1,325	Manual	Railway	1930	Brown-Boveri
Hershey Chocolate Company	1	600	500	500	Manual	Interurban-railway	1930	General Electric
I. G. Farbenindustrie for Standard Oil Co. of Louisiana	1	3,500/9,600	2,200	2,200	Manual	Electro-chemical	Being erected	Brown-Boveri
Iowa Nebraska Light & Power Co	1	600	1,000	1,000	Manual	Railway	1930	Brown-Boveri
Italian State Railways	2	2,900	2,000	4,000	Automatic	R. R. electrif'n	1930	General Electric
Long Island Railway Co	5	650	3,000	15,000	Automatic	Railway	Being erected	Brown-Boveri
Los Angeles Railway Corp	2	600	1,500	3,000	Automatic remote control	Railway	On order	General Electric
Montreal Tramways Co	2	600	1,500	3,000	Automatic remote control	Railway	Being erected	General Electric
Montreal Tramways Co	2	600	1,500	3,000	Automatic remote control	Railway	1930	General Electric
New York Board of Transportation	10	625	3,000	30,000	Automatic remote control	Subway	Being erected	General Electric
New York Board of Transportation	13	625	3,000	39,000	Automatic remote control	Subway	On order	General Electric
Northern Indiana Public Service Co	1	1,500	3,000	3,000	Automatic	Railway	Being erected	Brown-Boveri
Paris Orleans Railway, France	1	1,500	1,500	1,500	Automatic	R. R. electrif'n	On order	General Electric
Philadelphia, City of	2	630	2,500	5,000	Manual	Subway	1930	Brown-Boveri
Public Service Co. of No. Ill., Chicago	1	600	1,900	1,900	Manual	Railway	1930	Brown-Boveri
Public Service Co. of No. Ill., Chicago	1	600	1,900	1,900	Automatic	Railway	1930	Brown-Boveri
Quebec Power Co	1	550	1,200	1,200	Automatic	Railway	Being erected	Brown-Boveri
Regina, City of	1	575	1,200	1,200	Manual	Railway	On order	Brown-Boveri
Saskatoon, City of	1	575	600	600	Automatic	Railway	1930	Brown-Boveri
Trenton Transit Co	3	600	1,400	4,200	Manual	Railway	On order	Brown-Boveri
Totals:								
Put in service	33			75,225				
Being installed	26*			71,400*				
On order	29			79,275				
Grand total for year	88*			225,900*				

*In addition one spare 500-kw. rectifier tank (without transformer) was supplied.

on the Delaware, Lackawanna & Western Railroad Electrification (Fig. 16) was the outstanding event of this year. This is the first installation of 3,000-volt rectifiers in the United States and the first use anywhere

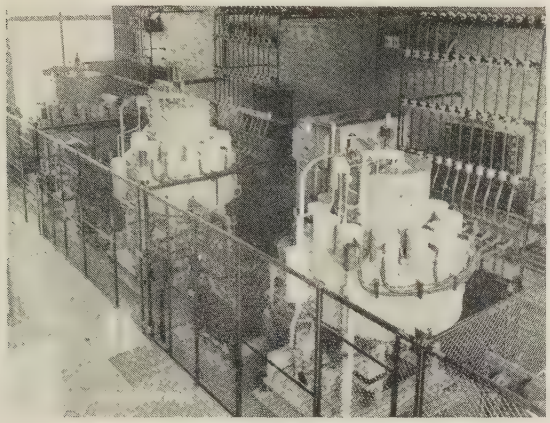

Fig. 16—3,000-Kw., 3,000-Volt, Mercury-Arc Rectifiers (GE)—Roseville Substation, Delaware, Lackawanna & Western R. R. Electrification

of so great a capacity of such units. It is also the first instance of a major railroad electrification relying entirely on rectifiers for the supply of power. These rectifiers are equipped with excited grids and with automatic compounding.

Another outstanding feature is the very large number of units ranging in voltage from 550 to 650 volts with a current rating in excess of 3,000 amperes, notable among which are 23 sets (GE) with an aggregate capacity of 69,000 kw. on order by the New York Board of Transportation. (The first seven units of this order were reported last year under the heading "City Subways of New York.")

Five units (BB), having a normal rating of 4,650 amperes at 650 volts, with overload ratings up to 15,000 amperes for twenty seconds, are being erected for the Long Island Railroad (Fig. 17). These rectifiers have eighteen anodes and normally operate from a 25-cycle source of supply but are arranged for immediate throw-over to a 60-cycle source of supply in the event of failure. The transformers are also suitable for operation at either 11 or 33 kv.

A 2,200-kw., high-voltage electric furnace set is also being erected (BB). The d-c. voltage may be varied from 3,500 to 9,600 volts by means of load-ratio control on the rectifier transformer. This is the highest voltage

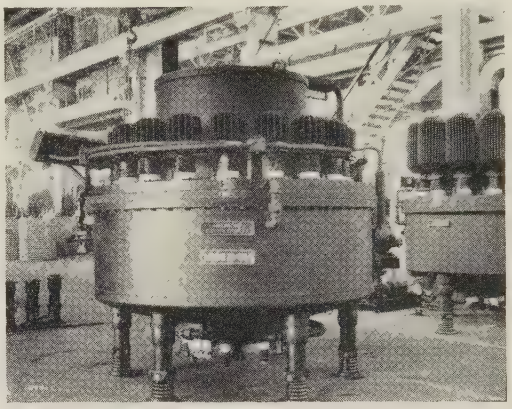

Fig. 17—3,000-Kw., 650-Volts, Mercury-Arc Rectifier (BB)—Long Island R. R.

for commercial rectifiers which has been reported in this country. Smaller units of higher voltage have, however, been used for large radio broadcasting stations in Europe.

Electrochemistry and Electrometallurgy

ANNUAL REPORT OF COMMITTEE ON ELECTROCHEMISTRY AND ELECTROMETALLURGY*

THIS report covers the period 1929 and 1930, inasmuch as no report was made in 1929.

It is believed worthwhile to indicate the magnitude of the electrochemical and electrometallurgical industries in terms of installed capacity and yearly power consumption. The figures for the United States are as follows:

Approximate installed operating capacity, kw	7,000,000
Approximate percentage of National total generating capacity	18
Approximate annual power consumption, kw-years	4,900,000
Approximate percentage of total	36
Number of workers	1,000,000
Value of product	$12,000,000,000

Quantities and percentages such as these would seem to warrant the liveliest interest on the part of men having electrical engineering training, particularly the younger men who find themselves faced with limited opportunities for advancement in those more standardized fields of the electrical art involving the design and manufacture of apparatus for the production and distribution of electrical energy. The development of new materials or processes based upon the utilization of this power is a field requiring talent of high order and one which it seems should be very attractive to men of electrical training who can and will superpose on an electrical background a knowledge of the fundamentals of physical chemistry.

Below is given a list of the more important industries whose basic processes are dependent upon the utilization of electricity for other than mechanical purposes:

Production of Metals by Wet Electrolysis. Copper, Nickel, Sodium, Zinc.

Production of Metals from Fused Electrolytes. Aluminum, Barium, Beryllium, Calcium, Magnesium.

Non-Metallic Electrolytic Products. Caustic, Chlorine, Hydrogen, Oxygen.

Electrothermic Products. Abrasives, Carbides, Carbon, Ferro-Alloys, Graphite, Refractories.

Miscellaneous. Cleaning and Surface Treatment of Metals, Dry Cells, Electric Steel Melting, Electrolytic Synthesis Organic Compounds, Electroplating, Electrostatic Precipitation, Inductive Melting and Heating, Nitrogen Fixation, Pasteurization and Sterilization, Secondary Batteries, Water Purification, Welding.

When the process problems of these industries are analyzed it will be found that they should be attacked by men who have been trained to deal with intangibles, and that most of the phenomena may be resolved into elements among which an electrical engineer who has been soundly trained in the basic science of his art should feel at home. Pursuit of these problems will probably lead him far from consideration of the newest thing in circle diagrams or the latest refinement in slot design but he will have broader scope for his imagination and the mental technique bred by electrical training.

The foregoing comments have been made because there are many who feel that the electrical industry is more in need of increased outlet for power than of further small gains in the efficiency of electrical apparatus *per se*, and that the great body of expectant young electrical engineers must look for adequate opportunities for advancement more to the fields of utilization and electrical processes than to the conventional ones of apparatus and generation.

Below is given an outline of the more important developments in electrochemical and electrometallurgical art that have become known during the past two years.

Copper

Although copper refining is probably the largest of the electrochemical industries in point of tonnage, no important modifications of electrochemical process have been reported although operating economies have been improved by advances in mechanical equipment and materials handling facilities.

Sodium

Metallic sodium is now being produced on such a large scale and so cheaply by electrolytic methods that it is the cheapest pure metal in terms of cost per unit volume. Its electrical conductivity is high enough so that its cost on a conductivity basis is lower than that of any other metal. These facts have led to a proposal that electrical conductors be formed of metallic sodium enclosed in a thin-walled tube of some non-magnetic alloy steel.

Metallic sodium is finding increasing application in connection with certain synthetic organic reactions

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whose nature is not disclosed and certain electrochemical interests are said to be preparing to manufacture sodium on an unprecedented scale.

Zinc

The success of electrolytic zinc refining plants was noted in the 1928 report of this committee. This development has since been subject to severe competition because of improvements in thermochemical methods. Electrothermal methods have also received the attention of investigators and it is probable that another year will see marked changes in zinc technology due directly to the application of electricity in one way or another.

Aluminum

The Hoopes process of producing very pure aluminum has become of increasing commercial importance, particularly for containers for various articles in the drug and pharmaceutical field. Although the electrical conductivity is appreciably higher than that of ordinary commercial aluminum it has not been commercially applied as electrical conductor material. Accurate alloy investigations have been made possible by this very pure material and the knowledge thus gained has assisted materially in the development of the strong aluminum alloys.

The usual Hall process rarely produces aluminum purer than 99.7 per cent, while the Hoopes process is regularly producing metal better than 99.98 per cent pure and some metal has been produced by this process having a purity of 99.99 per cent. The process is carried out in a three-layer cell, wherein the metal to be purified exists as a molten anode alloy and rests on the bottom of the cell. The electrolyte consists of a mixture of cryolite, aluminum fluoride and barium fluoride. The purified aluminum is electrolytically deposited in a layer of pure molten aluminum floating on top of the electrolyte. Graphite electrodes are employed to lead the current out of the aluminum layer. The cell operates at a voltage varying from 5 to 7 volts and normally a current of 20,000 amperes is employed.

By anodic treatment in wet electrolytic cells aluminum may be given a tough, adherent and corrosion resistant surface of oxide which serves as a base for color and which is also finding use for protection of aluminum alloy aircraft structure from severe corrosion attack such as that of salt spray and sea-water. This development is still going forward rapidly and is expected to become of much greater importance in aluminum technology.

Electro-plating with aluminum on copper and other base metals has been accomplished by the use of a fused electrolyte of low melting point comprising the chlorides of aluminum and sodium. Tough, adherent, and non-porous deposits of pure aluminum are produced and many commercial uses will no doubt be found as the technique is improved.

Barium

Barium is one of the alkaline-earth elements and is characterized by great reactivity and interesting thermionic properties. It is produced by the electrolysis of fused barium salts and has been receiving considerable attention because certain of its alloys have useful thermionic properties. It has found commercial application in a nickel-base alloy for spark plug electrodes and has been of interest as an essential constituent of alloys intended for use as cathodes in thermionic devices. Such barium alloys are, in general, electric furnace products.

Beryllium

During the past few years the metal beryllium has received a great deal of attention, which has been primarily due to the results of systematic research both in this country and abroad. Beryllium may be produced by an electrolytic process which consists of the electrolysis of mixed beryllium oxyfluoride and barium fluoride. The only commercial ore of beryllium is a silicate of beryllium and aluminum. The beryllium oxide content of available ores lies between 6 and 12 per cent. The production of beryllium has been carried out both in this country and abroad.

The future of beryllium does not appear to lie in its use as a basic material, but rather as a minor constituent in more or less complex alloys.

About the only use thus far developed for the pure metal is as windows in X-ray tubes, inasmuch as beryllium is extremely transparent to X-rays. Experimental use in pistons and piston rings has been reported. Continued research will doubtlessly develop new uses for this interesting metal, inasmuch as it possesses a combination of high elastic modulus, low expansivity and lightness which is very attractive to many who are interested in mechanical developments. Its electrical resistivity is approximately 6.7 microhms per cu. cm. at room temperature.

Magnesium

This metal is produced by the electrolysis of molten magnesium chloride and more recently by means of processes in which magnesium oxide is dissolved in a bath of fused fluorides and decomposed by electrolysis to give the metal. The production of magnesium in the United States has increased from approximately 50,000 lb. in 1921 to more than 1,000,000 lb. in 1930. During 1930 magnesium forgings have appeared on the American market and with continued research it is expected that increased quantities of strong magnesium alloys in the form of castings and forgings will be rather extensively employed particularly in aircraft. With improved production technique purer metal is being produced and the susceptibility to corrosion lessened in consequence.

The outstanding difficulty in the way of increasing the use of magnesium has been the development of

suitable alloys and fabricating processes and great strides are being made in this direction.

Electrotechnology of Gases

The treatment of gaseous mixtures by electrical discharges in order to effect chemical reactions that would not ordinarily occur has received a great deal of attention. The work of Fischer and Peters in Germany is particularly interesting in that they find it possible to produce acetylene from methane with an energy consumption that compares favorably with that required by the conventional calcium carbide process. The cracking of heavy hydrocarbon vapors by corona discharge also shows some possibilities. A great deal of research is going on in connection with the chlorination of hydrocarbons such as methane, pentane, etc., and this promises a considerable expansion in the use of chlorine, which is an electrolytic product. Research investigations of the chemical effects of bombardment by high-speed electrons should also be mentioned.

Abrasives—Carborundum

Tungsten carbide cutting tools have found increasing application and this has necessitated the development of improved abrasive wheels for shaping them. As a consequence special grades of carborundum are being made, apparently of unusual purity, from which grinding wheels specially adapted to the shaping of carbide tools are made. Carborundum base resistors for high temperature electric heating furnaces have been considerably improved, and several manufacturers have designed about this type of resistor commercial furnaces for operating temperatures between 1,000 deg. and 1,400 deg. cent.

Aluminum silicate refractories of very high melting point are being fused in electric furnaces and cast into blocks and shapes for various purposes, particularly for parts for glass-melting furnaces. The melting and casting of such highly refractory substances is a new and interesting departure in industrial ceramic technology.

Cleaning of Metals

A wet electrolytic process for the removal of scale from metals which is said to be competitive with pickling and free from many of its objections has been put on a commercial basis. Hydrogen embrittlement is prevented by the automatic deposition of a thin film of lead on any area of clean metal as soon as it is exposed by scale removal. This lead film may be allowed to remain as a protection against corrosion or removed by anodic oxidation by reversal of the electrolyzing current.

Electrochemical Standards

The interest in our electrochemical standards for the international ampere and the international volt has been continued and during the coming summer cooperative measurements on these standards will be carried out at the Physikalisch-Technische Reichsanstalt. For this purpose Dr. G. W. Vinal, Chief, Section of Electrochemistry, U. S. Bureau of Standards and a member of this Committee is being sent to Germany. He will also make measurements at the Laboratoire Central d'Electricite in Paris, and the National Physical Laboratory in England.

Primary and Secondary Batteries

During the past year the American standard for dry cells has been revised and a new standard approved by the American Standards Association. This standard has been published by the Association and also by the Bureau of Standards as Circular No. 390. The technical requirements of the Government specifications are identical with those of the American standard, but the Government specification is being revised to accord with the form prescribed by the Federal Specifications Board for all Government specifications.

The Federal specifications for automotive storage batteries have been approved and published during the year. These are designated as W-B-131 and are contained in section 4, part 5 of the Federal Standard Stock Catalog.

The past twelve months have witnessed a considerable decline in the demand for primary battery products in general due to the business depression and the reduction in the number of battery operated radio sets in active use. This has naturally affected most the production of B batteries, though the production of 6-in. dry cells, many of which were also used for radio, has been seriously affected as well. The demand for flashlight batteries seems actually to be on the increase due perhaps to the appearance on the market of a rather wide variety and a considerable number of inexpensive flashlight cases which have apparently been widely bought.

The general decrease in demand for battery products has resulted in a tendency to reduce prices and on the part of at least the larger manufacturers to strengthen quality. Many of the smaller manufacturers have been forced out of the business as a natural consequence.

The year has brought the development of the industrial flashlight battery intended for use by public service corporations, railroads, theaters, and manufacturing organizations where the demand on the battery is considerably heavier than in ordinary flashlight use. At a recent conference at the Bureau of Standards two tests were standardized as representative of the industrial types of service and this has greatly facilitated and intelligently guided the development of satisfactory cells for this specific application.

Special radio B batteries of superior performance have been developed in response to demand created by radio-equipped automobiles for police squad use as well as for privately owned machines.

In the 6-in. dry cell group there has been a further advance in the life of the better telephone cells. Certain makes have reached the remarkably high figure of 360 days on the standard light intermittent test which

compares with a maximum of about 180 days ten years ago.

An interesting new development which has occurred in the primary battery field during the past year is the introduction by one manufacturer of an air depolarized portable caustic soda battery designed primarily for use as an A battery for specially designed radio receivers using the new two-volt tubes and operated entirely by batteries. It is hoped that radio receivers of this type will develop wide application in rural districts where power is not available for operating electric radio sets and where storage batteries cannot be conveniently charged. This so-called air cell radio A battery is said to be good for a year's average service with one of these receivers. The basis of its operation is the absorption by a porous carbon electrode of the oxygen from the air which is carried to the surface of the electrolyte where it acts as a depolarizer for the cell. While the principle employed is not a new one, its application to a portable practical battery is believed to be new.

During the year, the revised American Standard for Dry Cells has been published, both by the American Standards Association of 29 West 39th Street, New York City, and by the Bureau of Standards in its Circular No. 390.

In the field of storage batteries the recent publication of the Federal Specification for Automotive Batteries, designated as W-B-131, may be mentioned.

A new storage battery, the Drumm alkaline cell, which involves the use of an electrolyte of potassium hydroxide with electrodes of nickel and other substances not disclosed, is said to provide reduced weight, increased efficiency, and the possibility of recharging in a 30 minute period. The e. m. f. is 1.5 volts. Successful trials in heavy trucking service are reported from England.

Electric Melting Furnaces

The demand for better metallurgical performance of arc furnaces is bringing about refinements in control gear among which are the use of tap-changing transformers to enable more precise voltage control and a tendency toward the adoption of hydraulic drive for electrodes, in which pilot valves responsive to furnace current, voltage or kva. operate to control fluid flow to the electrode driving cylinders. More prompt response, improved sensitivity and absence of hunting are said to be provided by hydraulic operation.

Induction furnaces of the submerged ring type are finding somewhat wider application owing to improvements in refractories and in a few places abroad have been used on high-nickel alloys and for superheating cast iron for high-strength castings.

Coreless induction furnaces operating at high frequency have found commercial application in sizes up to two tons, with power ratings up to 600 kw. High-frequency generating units of 1,250 kw. are being built to supply 3½ ton furnaces. A common frequency is 980 cycles, but the trend is downward, particularly for large units. Commercial frequencies have been successfully applied and one manufacturer has successfully operated experimental four-ton units at 60 cycles, the entire kva. requirement being supplied by a motor-generator set. Considerable attention has been given to the technique of refining in these induction furnaces and some success has been attained.

Oxygen-free copper from large inductively heated furnaces is a commercial possibility of the near future. Such a material would avoid some of the weaknesses of present commercial copper and in particular its tendency to embrittlement when subject to hot reducing gases. Unusually high ductility may make it interesting for some mechanical uses.

Control of furnace atmosphere, vacuum melting, and the distillation of metals are all receiving attention at the hand of investigators.

Water Purification

Electrolytic purification of water has been receiving considerable attention following the announcement, in Germany, of a process and apparatus in which water is passed through a succession of diaphram type electrolytic cells which cause concentration of ionogens in the electrode compartments. It is susceptible of large-scale operation but so far has been used mainly to complete the purification of distilled water.

Sterilization of Milk

The electropure process of milk conditioning effects pasteurization by passing the raw milk rapidly between carbon electrodes where it is heated by the passage of 60-cycle current. This scheme enables refinements in the control of the time and temperature variables that have hitherto been impracticable and the quality and uniformity of the product are thereby enhanced.

Electrostatic Precipitation

The results of test of improved hot-cathode vacuum rectifiers indicate that it will be possible to improve the operation and decrease the physical dimensions of the electrical end of precipitation plant. Increased use of powdered coal firing has caused the ash which is carried up the stack to be troublesome and electrostatic precipitator equipment is finding application in this connection. The same fundamental ideas are being applied to the separation of suspended solids from liquids. The purification of insulating oils is a case in point and it is stated that by electrostatic cleaning higher breakdown values can be obtained than by methods now in general use.

Metal Powders

Finely divided metals find numerous uses in chemical technology and as pigment in the decorative arts. Electrolytic means have been developed for producing copper, tin, nickel, silver, and lead in crystalline form in sizes as fine as 500 mesh.

Miscellaneous Process and Plant

Mercury-Arc Rectifiers

There are under construction for a Canadian Plant mercury-arc rectifiers rated at 6,500 kw. each (10,000 amperes, 650 volts) to be used for the electrolytic production of hydrogen.

Rotary Converters

Another electro-chemical plant has installed synchronous converters with load ratio control type transformers to furnish direct current for an electrolytic process. These machines are rated at 5,440 kw. each (16,000 amperes, 340/370 volts). These machines are also of interest because of their use of volute housings as part of the ventilation system.

Electrodeposition of Tungsten

The electrodeposition of tungsten in the wet way from alkaline baths has been accomplished on a laboratory scale. Tungsten possesses such marked resistance to acid attack and to wear that this development may prove to be of considerable industrial importance.

Heat Treating Furnaces

A marked interest was shown by the steel industry in the use of electric furnaces for heat treatment service. One plant installed two 1,100-kw. resistor type furnaces 50 tons capacity each, one 1,000-kw. similar furnace, and other furnaces, making a total of 4,500 kw.

The use of artificial atmospheres in electric furnaces for heat treatment processes is making considerable progress. One steel plant has installed 2,000 kw. in furnace capacity for bright annealing of steel strip.

Electrically heated and controlled apparatus for controlling the composition of the gases used are coming into evidence.

The special requirements of the nitriding process which involves heating to approximately 550 deg. cent. articles of special alloy steel (containing small amounts of Cr, Al, Mo, and Ni) in an atmosphere of ammonia has led to the development of furnaces with special provisions for circulating the ammonia. Heat transfer is effected by forced convection instead of by radiation. It appears possible that the application of this principle will find extended application in special-purpose furnaces in which control of atmosphere is important.

In both the heat-treating and melting fields the refinements of metallurgical technique and the growing recognition of the value of high quality and uniformity of product have brought about such profound changes in the design and operation of furnaces that they are coming to resemble machine tools rather than the piles of brick that the word usually calls to mind.

Conclusions

It is believed that this report reflects the more important trends in electrical process technology and hoped that it may draw the attention of electrically trained men to the very interesting possibilities in the field of the development of processes and materials dependent upon the forces that only electricity can bring into play.

The Chairman wishes to acknowledge the assistance given by members of the Committee and by numerous individuals in the preparation of this report which is respectfully submitted on behalf of the Committee on Electrochemistry and Electrometallurgy.

Electrophysics

ANNUAL REPORT OF THE COMMITTEE ON ELECTROPHYSICS*

THE annual report of the Committee on Electrophysics has generally taken the form of an account of the progress in the field of electrophysics during the preceding year. In view of the steady increase of the activity in this field the matter to be covered has increased greatly, and the report for the year 1929-1930 was a lengthy one in spite of all efforts to keep its size down to a minimum.

At a meeting of the committee held January 30, 1931 its field of activity and in particular its annual report were discussed at considerable length. It was the sense of the committee that it was one of the most important of its functions to bring to the attention of electrical engineers the progress being made in electrophysics. It was felt very strongly, however, that this cannot be done in the best possible fashion by reporting the progress for a year at one time and publishing it as a unit. Accordingly, the committee decided that it could be of much greater service to the engineering profession if its reviews of the progress in electrophysics were published from time to time by subjects instead of annually as a unit. As a result the plan was adopted of publishing reviews of the progress of electrophysics by subjects in ELECTRICAL ENGINEERING. Each contribution will aim to cover the progress in its particular field from the date of the preceding report as nearly up to the date of publication as is possible. A tentative schedule of the proposed subjects is as follows:

Magnetism and Magnetic Materials.
Propagation of Electric Waves.
Electric Discharges in Gases.
Dielectrics.
Thermionics and Photoelectricity.
Vacuum Gas Discharge and Photoelectric Tubes.
Electric Conduction in Solids.
Electromagnetic Theory.

In addition the Committee plans to sponsor from time to time for publication in ELECTRICAL ENGINEERING papers by recognized authorities on various subjects in electrophysics of interest to electrical engineers. One such paper is published herewith. After all the reviews for any one year have been published, they may be collected and published together in the TRANSACTIONS if it should be considered desirable.

*COMMITTEE ON ELECTROPHYSICS:
Oliver E. Buckley, Chairman,
V. Bush,
W. G. Cady,
W. F. Davidson,
D. L. Fortescue,
W. S. Gorton,
W. B. Kouwenhoven,
G. M. J. Mackay,
K. B. McEachron,
L. W. McKeehan,
H. Nyquist,
Leigh Page,
W. S. Rodman,
J. Slepian,
W. F. G. Swann.

Magnetism and Magnetic Materials

The following review of progress in magnetism and magnetic materials covers the period since the last report of the Electrophysics Committee. The progress in other phases of electrophysics will be covered similarly in succeeding reviews. The Committee also may offer from time to time papers on subjects in electrophysics of interest to electrical engineers.

MAGNETISM

Our understanding of ferromagnetism has advanced during the period since our last report (JL. A. I. E. E. **49**, 721, 1930) in several important respects. Heisenberg's interaction theory, which refers the stability of magnetization to the low potential energy of codirected electron spins in neighboring atoms, has been applied by Powell (*Proc. Phys. Soc.* **42**, 390, 1930) to explain the change in dimensions which take place when iron and nickel lose their ferromagnetism on heating. This change, a decrease in the case of iron, an increase in the case of nickel, is isotropic, being thus wholly unlike the principal part of magnetostriction which differs greatly in different crystallographic directions. It is concluded from the fact that both signs of change occur that some account must be taken, at least in the case of iron and probably in all cases, of atoms more remote than the immediate neighbors. Becker and Kirsten (*Zeitsch. f. Physik* **64**, 660, 1930) who identify the stabilizing forces with internal elastic strains, have succeeded in getting rather good agreement between the permeability of highly stressed nickel as measured and as calculated from limiting magnetostriction and the elastic moduli. Rankin (*J. Roy. Tech. Coll.* Glasgow **2**, 385, 1931) has continued his experiments on magnetostriction in overstrained metals. Akulov has continued his discussions of the relations between magnetostriction, magneto-resistance and elasticity concluding in his latest papers (*Zeitsch. f. Physik* **67**, 794, 1931; *Phys. Zeits.* **32**, 107, 1931) that the magnetic behavior of single crystals is fully explained by a dual process of reversals and rotations of the magnetic elements and that the magnetic properties of polycrystalline metal *without large scale anisotropy* can be calculated from data obtained for monocrystals. McKeehan (*Rev. Mod. Phys.* **2**, 477, 1930; **3**, 190, 1931) has reviewed the content and relations between the current theories of ferromagnetism and some of the recent experimental evidence pertinent thereto.

Several papers, in addition to that of Powell, already referred to, deal with the experimental and theoretical

aspects of the Curie point. Tyler (*Phil. Mag.* [7] **11**, 596, 1931) shows that the decrease of apparent saturation values with rise of temperature is practically according to the same law for iron, cobalt, and nickel, and that this is consistent with the idea that in all three metals single spinning electrons are free to change their axial direction, although in all these cases the average number of such magnetizable electrons per atom is greater than one. According to these data, therefore the ferromagnetic unit is sub-atomic rather than atomic. Above the Curie point it appears (Stoner, *Phil. Mag.* [7] **10**, 27, 1930) that atoms begin to act as units. Forrer and Hoffmann (*Comptes Rendus* **191**, 1046, 1930) present new evidence for a doubling of the (ferromagnetic) Curie point in nickel, the coercive force first decreasing, then increasing, and finally decreasing again as the temperature rises. An apparent disagreement between two experimenters, Weiss and Bates, in regard to the temperature at which the specific heat anomaly becomes greatest as the Curie point is approached has been dissolved by new evidence. Bates (*Proc. Phys. Soc.* **42**, 441, 1930; **43**, 87, 1931) now also finds this temperature to be where $-d\,I^2/d\,T$ is maximum; his earlier experiments were vitiated by an irreversible change in the properties of his material (manganese arsenide) produced by the small rise in temperature (magneto-caloric effect) associated with applying the magnetizing field. Incidentally, the specific heat anomaly is here far too large to be ascribed to an elementary magnet like that in iron or nickel.

The anomalous temperature coefficient of electrical resistance for ferromagnetics near their Curie points is closely associated with their magnetizability. Gerlach (*Zeitsch. f. Physik* **59**, 847, 1930; *Ann. der Physik* [5] **6**, 772, 1930) and Borelius (*Ann. der Physik* [5] **8**, 261, 1931) present opposing opinions regarding the anomaly. The former in agreement with earlier work of Cabrera regards the high-temperature state (above the Curie point) as normal and the low-temperature state as possessing an abnormally low resistance, the latter supports the contrary view that it is the low-temperature or completely magnetized state which has normal resistance. The transition as the Curie Point is approached from below is the same whichever view is taken.

The closely related subject of heat production during magnetization and demagnetization has been examined in a preliminary way by Gilbert (*Comptes Rendus* **191**, 1309, 1930) who finds no cooling in cobalt steel at H up to 18,000 except that attributable to the magneto-caloric effect of Weiss. The more complete report of Ellwood's results (*Phys. Rev.* [2] **36**, 1066, 1930) confirms his earlier finding of a cooling in carbon steel at low values of H on the ascending branch of a loop, and announces a second stage of cooling at moderate values of H. It should be noted that the magneto-caloric effect would account only for a minute heating in this part of the loop.

An effort has been made by Bitter (*Phys. Rev.* [2] **37**, 91, 1931) to coordinate ferromagnetic behavior with the small scale imperfection of metallic crystals recently predicted by Zwicky (*Helvetica Physica Acta* **3**, 269, 466, 1930; **4**, 49, 1931). Frenkel and Dorfman (*Nature* **126**, 274, 1930) deal with the same problem on purely thermodynamic principles, deciding that a large crystal cannot act as a magnetic unit.

Experiments on the Barkhausen effect in a rotating magnetic field (Cisman, *Ann. der Physik* [5] **6**, 825, 1930), make it more plausible than ever to suppose that the occurrence of a discontinuity in magnetization requires a definite degree of divergence between the applied field and the local magnetization. There is, in fact, a decided parallelism between Cisman's Barkhausen effects and hysteresis in rotating fields, most recently studied by Seiyama (*Mem. Kyushu Univ. Coll. Engg.* **5**, 227, 1930). Heaps and Bryan (*Phys. Rev.* [2] **36**, 326, 1930) have shown that large changes in magnetization and in magnetostriction are simultaneous. Bozorth has just discovered (*Nature* **127**, xxx, 1931) that in a very slowly changing magnetic field the Barkhausen discontinuities which can be detected by a high-speed oscillograph occur in closely grouped sets with quiet intervals between them. These compound events, in proximate analysis, can easily be mistaken for single events. This apparently explains the wide disagreement between published statements as to the volume of metal affected in a single discontinuity. The time required for the spreading of a major magnetic disturbance has been studied by Sixtus and Tonks (*Phys. Rev.* [2] **36**, 1441, 1930).

The gyromagnetic effect, hitherto only observed in ferromagnetic materials—most recently by Barnett (*Phys. Rev.* [2] **36**, 789, 1930)—has now been measured for a paramagnetic material by Sucksmith (*Proc. Roy. Soc.* [*A*] **128**, 276, 1930; *Proc. Phys. Soc.* **42**, 385, 1930). The phenomenon is merely easier to observe in ferromagnetics on account of their easier magnetization.

In studies on diamagnetic and weakly paramagnetic metals the theory has been improved by Landau (*Zeitsch. f. Physik* **64**, 629, 1930) and Teller (*Zeitsch. f. Physik* **67**, 311, 1931) so that better predictions are now possible as to the diamagnetism to be expected from conduction electrons. On the experimental side relatively enormous changes in susceptibility—much larger than the changes in conductivity make probable—have been reported by Honda and Shimizu (*Nature* **126**, 990, 1927) and by Bitter (*Phys. Rev.* [2] **36**, 978, 1930), both of whom measured the susceptibility of copper as affected by cold work and annealing. Banta (*Phys. Rev.* [2] **37**, 634, 1931) has attempted without success to duplicate Bitter's findings.

Spectroscopic evidence that some atomic nuclei have a small magnetic moment continues to accumulate (Fermi, *Zeitsch. f. Physik* **60**, 320, 1930; Goudsmit and Young, *Phys. Rev.* [2] **35**, 1418, 1930; Frisch and Ferchmin, *Naturwiss*, **18**, 866, 1930). The effect upon gross magnetic properties of such nuclear magnetic

noments as have yet been shown to exist must be very small.

Effects of magnetic fields on electrical resistance and electric potential with or without the presence of thermal currents and temperature differences have been reviewed on the basis of the new electron theory of metals by Sommerfeld and Frank (*Rev. Mod. Phys.* **3**, , 1931). The proper mode of description of these galvanoelectric, thermoelectric, galvanomagnetic and thermomagnetic effects have been discussed by Perrier (*Helvetica Physica Acta* **3**, 317, 400, 1930). The conditions are especially complicated in the case of ferromagnetics. Pugh (*Phys. Rev.* [2] **36**, 1503, 1930) has shown for iron that the magnetization, I, or the ferromagnetic induction, B-H, is more important than either H or B in fixing the magnitude of the Hall e. m. f. Stierstadt (*Zeitsch. f. Physik* **65**, 575, 1930; **67**, 725, 1931) has studied magneto-resistance in electrolytic iron for both longitudinal and transverse magnetizations. Williams and Sanderson (*Phys. Rev.* [2] **37**, 309, 1931) present new data on magneto-resistance in nickel strips of different mechanical history.

The magneto-resistance of bismuth single crystals at extremely low temperatures, below 20 deg. K, has been studied in detail by Schubnikow and de Haas (*Nature* **126**, 500, 1930; *Proc. Amsterdam Acad.* **33**, 363, 418, 1930), who find a whole series of unexpected phenomena. Unlike the magneto-resistance at higher temperatures the relative change in resistance is no longer a smoothly varying function of the applied field, H, nor of the azimuth in any crystallographic plane yet examined. At higher temperatures, however, theory has caught up with experiment, for Frank (*Zeitsch. f. Physik* **64**, 650, 1930) has shown that the straightening out of $\Delta R/R$ *vs.* H curves at high H values, first observed by Kapitza, is completely accounted for by the quantum theory of electronic conduction. The parabolic increase of $\Delta R/R$, formerly supposed to be called for by the theory, is only possible for relatively limited ranges in H.

One of the most puzzling experimental results recently published is that of Allison and Murphy (*Am. Chem. Soc. Jl.*, **52**, 3796, 1930), who report that the magnetic double refraction (Faraday Effect) in certain solutions is characteristic, not only of the elements present but even of the number of isotopes of each, and furnishes a highly sensitive means for chemical analysis.

In the domain of magnetometry Sanford has been investigating magnetic permeameters, particularly those for use at high inductions (*Bu. Std. J. Res.* **4**, 177, 703, 1930; **6**, 355, 1931). A new level of precision in magnetic curve tracing has been attained by Haworth (*Bell System Tech. Jl.* **10**, 20, 1931; *Rev. Scient. Instr.* [N. S.] **2**, 125, 1931) who compensates the torque of a fluxmeter suspension by a photoelectric current depending upon the momentary deflection. Brüche (*Zeitsch. f. tech. Physik* **12**, 94, 1931) has considerably refined the methods for exploring magnetic fields by narrow beams of cathode rays. Freed and Kasper (*Phys. Rev.* [2] **36**, 1002, 1930) have improved the accuracy of Gouy's method for measuring the susceptibility of weakly magnetic solutions.

A stimulating book by S. R. Williams[1] gives a readable account of the experimental side of the subject of magnetism, with especial emphasis on ferromagnetism.

An important announcement regarding magnetic units as adopted by the International Electrotechnical Commission was made by Dr. Kennelly at the Winter Convention in New York. The electrophysics committee is by no means unanimously in accord with the suggestions of the international body. Some of our members feel that the already existing confusion in regard to the physical significance of B and H is increased rather than diminished by giving physical dimensions to their ratio. It is interesting to notice that a body of German engineers went even farther than the I. E. C. in the effort to rationalize empirical relations (*Elektrotech. u. Maschinenbau* **48**, 950, 1930).

Magnetic Materials

The results of many investigations carried out in the past three or four years confirm the view that crystal grain size is one of the important factors in magnetic materials. Yensen (*Metals and Alloys*, **1**, 493-495; 1930) has proposed an expression for the hysteresis loss in iron in terms of the crystal grain size and impurities in the metal, leading to the conclusion that for perfect single crystals, free from impurities and internal strain, the hysteresis loss vanishes. Gerlach has more recently arrived at a similar conclusion. (*Zeitsch. f. Physik*, **64**, 502-506; 1930). On the other hand Von Auwers and Sizoo (*Zeitsch. f. Physik*, **60**, 576-580; 1930) conclude that crystal grain size has much less influence on remanence than on hysteresis loss and coercive force.

What promises to be of great importance is the announcement by Cioffi (*Nature*, **126**, 200-201; 1930) that ordinary polycrystalline iron may be made to acquire very high permeability by heat treating at high temperature in hydrogen. The reported initial and maximum permeabilities are 6,000 and 130,000, respectively, and the coercive force and hysteresis loss are respectively 0.05 gauss and 300 ergs/cu. cm./cycle, for $B_m = 14{,}000$. Later unpublished values give 180,000 for the maximum permeability, 0.025 gauss for the coercive force and 190 ergs/cu. cm./cycle for the hysteresis loss for the same maximum induction. These properties are ascribed partly to purification of the iron and partly to the hydrogen actually absorbed in the metal. Further correlation appears to be necessary between crystal grain size and magnetic properties in view of these results, since the grain size of this material appears to be of little importance.

The existence of the A_3 point in carefully purified iron occurring reversibly between 907 deg. cent. and

1. "Magnetic Phenomena," McGraw-Hill, 1931.

910 deg. cent. has been confirmed by Roberts and Davey (*Metals and Alloys* **1**, 648-654; 1930), by X-ray crystallographic determinations. This fact has recently been a matter of some dispute (Yensen, A. I. M. & M. E., *Inst. Metals Div.*, 320-332; disc. 332-349; 1929).

The increasing importance of nitrided steels has led to further investigations of the iron-nitrogen system. Qualitative and quantitative measurements by Lehrer (*Zeitschr. f. Electrochem.*, **36**, 460-473; 1930) by means of magnetization-temperature curves have been used to construct the equilibrium diagram for the iron-nitrogen system. The results show that up to 11 per cent nitrogen there are four phases, in agreement with the X-ray determinations of Hägg (*Zeitsch. f. Physik. Chem.* **8**, 455-474; 1930) and Eisenhut and Kaupp (*Zeitschr. f. Electrochem.* **36**, 392-404; 1930). Köster (*Archiv. f. Eisenhüttenwesen* **3**, 637-648; 1930) has shown that nitrogen in α-iron remains in supersaturated solution even after slow cooling, requiring prolonged heating at low temperatures for complete separation, with a resultant increase in conductivity and increase in coercive force from 4 to 7 gauss. The segregation of nitrogen in the supersaturated solution is further accelerated by cold working (*Archiv f. Eisenhüttenwesen*, **3**, 649-658; 1930).

A number of alloys of iron and non-magnetic elements has been investigated. Pure electrolytic iron having a trace of phosphorus has been found to have better magnetic properties than commercial silicon steel. (*Gayler, Metallwirtschaft*, **9**, 677-679; 1930.) The iron-silicon system has been studied by Haughton and Becker, (*Iron and Steel Inst. Jl.*, **121**, 315-335; 1930) using metals of higher purity than heretofore. The existence of phases corresponding to the compounds FeSi, and Fe_3Si_2 have been confirmed, and in addition a phase which is probably the compound Fe_2Si_5. The addition of 14.5 per cent silicon lowers the Curie point of iron to 490 deg. cent. A magnetic transformation point occurring at 82 deg. cent. in the Fe_3Si_2 phase confirms the earlier work of Murakami (*Tohoku Imp. Univ. Sci. Rep.*, **10**, 79-92, 1921). Oya (*Tohoku Imp. Univ. Sci. Rep.* **19**, 235-245; 1930) has found that additions of vanadium to iron first raise the Curie point then depress it, so that it is room temperature for 35 per cent vanadium. The alloys of iron and chromium with approximately 18 per cent chromium have been found to have zero magnetostriction (Dean, *Rensselaer Polytech. Inst. Bull. No. 26*, Eng. and Sci. Series; 1930). Fischer (*Rensselaer Polytech. Inst. Bull. No. 28*, Eng. & Sci. Series; 1930) has found that this range of alloys has higher permeability and is less sensitive to quenching strains than other alloys of this group. This behavior has already been observed in permalloy (Buckley and McKeehan, **26**, 261-273; 1925) and is in accordance with McKeehan's theory of magnetostriction (*Phys. Rev.* **28**, 158-166; 1926). Kussmann, Scharnow, and Messkin (*Stahl u. Eisen*, **50**, 1194-1197; 1930) have found that additions of copper up to 0.7 per cent increase the resistance of iron to corrosion without impairing its magnetic and electrical properties. A general deterioration of these properties is obtained for higher copper concentrations.

The relation of magnetic properties to mechanical hardness has been investigated by Messkin (*Stahl u. Eisen*, **50**, 105-106; 1930) who has found that cold rolling increases the remanence and coercive force of carbon steel; and by Herbert (*Proc. Roy. Soc.*, **130**, 514-523; 1930) who has observed age hardening of steel and non-magnetic metals subjected to a changing magnetic field.

Sachse and Hasse have found that (*Zeitsch. f. Physik Chem.*, [A] **148**, 401-412; 1930) regular crystals of ferromagnetic ferric oxide, Fe_2O_3, are unstable at all temperatures, the susceptibility falling by 60 per cent in 4 years at room temperature. The fact that ferric oxide has 10^{-10} the conductivity of the ferromagnetic metals, leads Sachse (*Zeitsch. f. Phys. Chem.*, [B] **9**, 83-91; 1930) to conclude that free electrons cannot be concerned in its magnetic properties. The ferrites of magnesium, lead, copper, and nickel are also ferromagnetic at ordinary temperatures, cadmium ferrite being sometimes ferromagnetic and sometimes paramagnetic (Holgersson and Serres, *Comptes Rendus*, **191**, 35-37; 1930). In mixtures of Fe_2O_3, NiO, and C_0O, Veil (*Comptes Rendus*, **190**, 181-183; 1930) has found a higher coefficient of magnetization for the composition represented by $(Fe_2O_3)_2\ NiOC_0O$.

A somewhat higher Curie point has been obtained for nickel by Jordan and Swanger (*Bur. Std. Jl. of Res.* **5**, 1291-1307; 1930) which is believed to be due to the greater purity of their nickel specimen. Sadron has found that (*Comptes Rendus*, **190**, 1339-1340; 1930) small additions of chromium to nickel, causes the saturation value at absolute zero to diminish linearly with chromium content, the Curie point for an alloy with 12 per cent Cr being absolute zero.

Widespread interest in the nickel-iron alloys coming under the collective name of permalloy is indicated by its numerous modifications to meet specific needs. Elmen has obtained very high initial permeability and resistivity in nickel-iron alloys by additions of molybdenum, chromium or tungsten (U. S. Pat. 1,757,178; *Jl. Frank. Inst.* **207**, 583-618; 1929). Stäblein (U. S. Pat. 1,760,326) has obtained high resistivity by additions of silicon. Bandur (U. S. Pat. 1,743,089) and Yensen (*Elec. Jl.* **27**, 214-218; 1930) report that with suitable heat treatment some nickel-iron alloys may be made to acquire sensibly constant permeability over a limited range of induction. Similarly, Smith and Garnett (U. S. Pat. 1,746,500) have obtained substantially constant permeability in nickel-iron alloys by additions of copper. Also, Gumlich, Steinhaus, Kussmann and Scharnow (*E. N. T.*, **7**, 231-235; 1930) report that high resistivity and small variation of permeability with magnetizing force are obtained in nickel-iron alloys by small additions of manganese.

Von Auwers, (*Wiss. Veroffentlich Siemens-Konzern* **9**, 262-293; 1930) has studied the effect of strain on the

magnetic properties of permalloy. The results of numerous experiments indicate that the properties of permalloy cannot be accounted for on the basis of strain alone.

Methods of design and testing of permanent magnets have kept abreast with the improvements in magnetic properties. Elenbaas (*Physica*, **10**, 273-286; 1930) has derived a formula for calculating the field intensity in a toroid with an air-gap, based on the assumption that the demagnetization curve is an ellipse; this should prove useful in the design of permanent magnets. It is well known that the magnetization of a ferromagnetic material by a steady field is considerably increased by the superposition of an alternating field. Schrankow and Janowsky (*Zeitsch. f. tech. Physik* **11**, 429-432, 1930) apply this method of bringing permanent magnets to high inductions. An accurate method of testing bent permanent magnets has been described by Webb and Ford (*I. E. E. Jl.*, **68**, 773-778; 1930) whereby both B and H are measured by means of search coils and a ballistic galvanometer. The superior properties of cobalt-steel as permanent magnets have found application in the magnetic compass for aircraft, disturbances from stray magnetic fields being avoided by shielding with hipernik, a nickel-iron alloy of high permeability (J. R. Gier, *Elec. Jl.*, **27**, 114-115; 1930).

The need for accurate and constant substandards of frequency has stimulated further work on vacuum tube oscillators controlled by the resonant magnetostrictive vibrations of magnetic materials. This method of control requires the use of materials which have good magnetostrictive properties and small temperature coefficients of permeability and expansion. Vincent (*Proc. Phys. Soc.* **43**, 157-165; 1931) has extended the range of the magnetostriction oscillator of Pierce, (*Proc. Am. Acad. Sci.*, **63**, 1-47; 1928) to radio frequencies by using corronil, a nickel-copper-manganese alloy, and glowray, a nickel-iron-chromium alloy (*Proc. Phys. Soc.* **41**, 476-486; 1929); the latter, particularly, has a high degree of stability. Smith (*Proc. Phys. Soc.* **42**, 181-189; 1930) has determined the nature and magnitude of the coupling between the mechanical vibrator and the electric circuit for a toroidal specimen of a nickel-iron alloy vibrating radially in its fundamental mode. Muzzey (*Phys. Rev.* **36**, 935-947; 1930) has used the magnetostriction oscillator as a means of exciting cylinders of stainless steel in studying the dependency of frequency of vibration on length and diameter of the cylinders.

ACKNOWLEDGMENT

The Committee is indebted to Professor L. W. McKeehan, of its membership, and to Mr. P. P. Cioffi for material for this report.

General Power Applications

ANNUAL REPORT OF COMMITTEE ON GENERAL POWER APPLICATIONS*

THE principal activity of the Committee during the past year has been in arranging and carrying out of plans for the Industrial Session held at the Winter Convention. As this Committee is interested in the application of electricity to all industries which are not specifically covered by other committees of the Institute, it was agreed that papers to be of interest to the greatest number of engineers should be of a general nature and not confined to a specific industry or application. The papers presented were consequently arranged and prepared with this thought in mind. During this period of industrial depression an increasing amount of attention is being given to the subject of reducing manufacturing costs and it was hoped that industrial engineers would find in these papers various ideas which could be applied to their own problems.

Industrial Papers Presented

Besides those papers presented at the Winter Convention several other papers of an industrial nature were presented at district meetings. Following is a list of those papers which have come to our attention:

Philadelphia Meeting Oct. 13 to 15, 1930:

Air Conditioning in Industry, by A. H. Clogston of the Cooling and Air Conditioning Corp.

A New System of Speed Control—A-C. Motor-Driven Power Station Auxiliaries, by A. M. Rossman of Sargent and Lundy, Inc.

Louisville Meeting, Nov. 19 to 22, 1930:

Electricity in the Cement Industry, by R. H. Rogers of the General Electric Company.

Electric Power in the Lumber Industry, by A. H. Onstad of Weyerhaeuser Timber Co.

Winter Convention, January 26 to 30, 1931:

Electron Tubes in Industry, by W. R. King of General Electric Co.

Automatic Regulators in Industry, by J. H. Ashbaugh, Westinghouse Electric and Manufacturing Co.

Electrical Distribution Systems for Industrial Plants, by W. J. McClain, of Louis T. Klauder Co.

The Synchronous Motor with Phase-Connected Damper Winding as a Drive for High-Torque Loads, by M. A. Hyde, Jr., Westinghouse Electric and Manufacturing Co.

The Design and Application of Synchronous Motors to Meet Special Requirements, by D. W. McLenegan and A. G. Ferriss of General Electric Co.

Pittsburgh Meeting, March 11 to 13, 1931:

Conversion and Distribution of General Purpose D-C. Power in Large Industrial Plants, by R. D. Abbiss, Carnegie Steel Co. and D. C. West, Westinghouse Electric and Manufacturing Co.

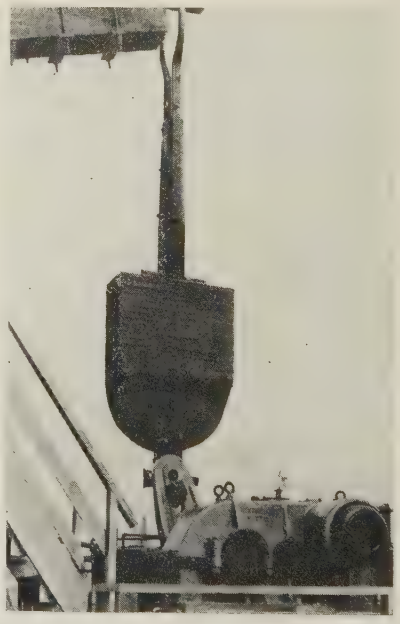

Fig. 1—Combination Pumping Unit for Oil Wells Including Motor, Gears, and Control

Symposium on *Interconnection Between Utilities and Industries.* Several papers.

The Use of Electricity in Large Annealing Furnaces, by J. C. Woodson, Westinghouse Electric and Manufacturing Co.

A Modern Electrified Dairy Plant, by A. J. Dreux, Reick-McJunkin Dairy Co. and H. C. Brunner, Westinghouse Electric and Manufacturing Co.

Review of Industrial Progress

Since the past year has not been one of great industrial development or activity, it is felt that this report

*COMMITTEE ON GENERAL POWER APPLICATIONS:

C. W. Drake, Chairman,
E. A. Armstrong, James Clark, Jr., J. F. Gaskill, Clyde D. Gray, John Grotzinger, Fraser Jeffrey, A. M. MacCutcheon, H. A. Maxfield, John Morse, N. L. Mortensen, A. M. Perry, D. M. Petty, F. O. Prior, H. W. Rogers, L. D. Rowell, M. R. Woodward.

should include not only a review of the major industrial developments but also should indicate the trend of development along both application and apparatus lines in industry.

Petroleum Industry

During the past year pipe-line transportation of liquid fuel over long distances has been extended to

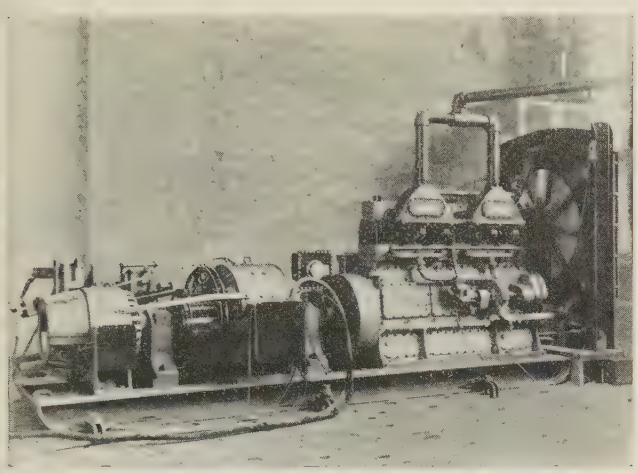

Fig. 2—Portable Diesel Engine-Driven Set for Variable Voltage Oil Well Drilling Outfits (Shop View)

include gasoline. Electric pumping stations supplied with central station service, are increasing in number and proving their economy. The latest development is an electric station with three 800-hp. pumping units which is completely controlled from a dispatching office about 15 miles away. This is the Sand Springs Station of the Texas Empire Pipe Line that connects Oklahoma oil fields with the Chicago refineries. The

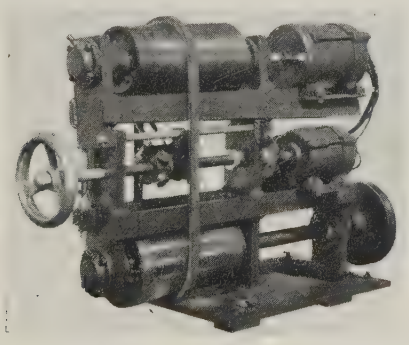

Fig. 3—Selsyn Generator and Cone Pulleys for Sectional Paper Machine Drive

supervisory control permits the dispatcher to exercise complete control over the station and gives a visual indication of its operation. The dispatcher can tell at a glance what units are operating, what the intake and discharge pressures are and as much other pertinent information as could be obtained if the operator were in the station. In case of trouble the equipment is shut down automatically and the dispatcher advised of the nature of the trouble.

Development in electrical oil field pumping and drilling equipment has been towards the use of combination, or factory assembled apparatus which eliminates many parts and reduces the installation expense in the field. One of the latest pumping units consists of a combination of gear, motor, and control built in one unit. The equipment is weatherproof and requires no housing. The unit is also provided with change gears for obtaining several speeds as required for various pumping conditions.

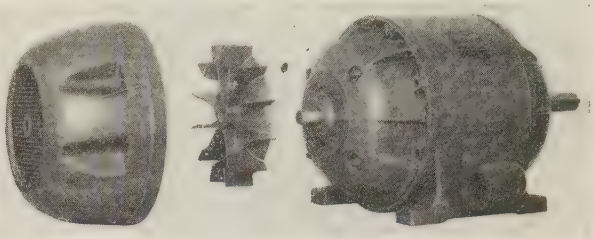

Fig. 4—Totally Enclosed Fan-Cooled Motor with Fan and Fan Casing Removed

During the past year several variable voltage d-c. oil well rotary drilling outfits have been built and put in service, using Diesel engines as prime movers. These outfits are being used primarily on locations where central station power is not available. The ease and simplicity of control obtainable with the variable voltage d-c. system, its low energy requirement and flexible operating characteristics, make this system very desirable for this type of oil service.

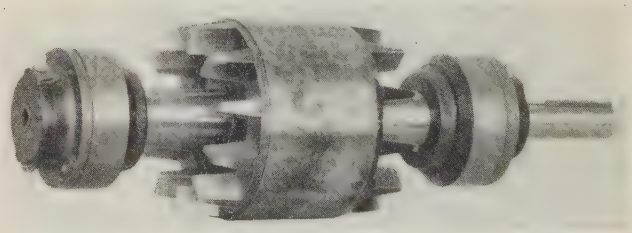

Fig. 5—Induction Motor Rotor Showing Cartridge Type Ball-Bearing Housings

Two installations are also reported where standard a-c. drilling equipments were installed and supplied with power from Diesel engine-driven generators, and, although this system may lack some of the desirable features of the variable voltage system, it makes it possible to use standard a-c. motors for pumping and other uses.

Pulp and Paper Industry

Sectional paper machine drives were installed during the year on a wide variety of machines from low-speed cylinder to high-speed fourdrinier and the use of section regulators of the carbon pile type instead of the contact

making type was quite noticeable. A description of some of these carbon pile regulators is given in Mr. Ashbaugh's paper, presented at the Winter Convention.

A regulator for sectional drives using Selsyn equipment so that the main regulating equipment may be mounted remote from the paper machine has been placed in operation during the year. At the paper machine, in connection with each sectional motor, is a Selsyn generator driven through suitable cone pulleys which provide necessary speed adjustment or "draw" between the various sections. The resistance elements of the regulator are of the carbon pile type.

Rural Electrification

The use of electricity on the farm has increased rapidly during the past year and reports from central stations indicate that approximately 90,000 farms were

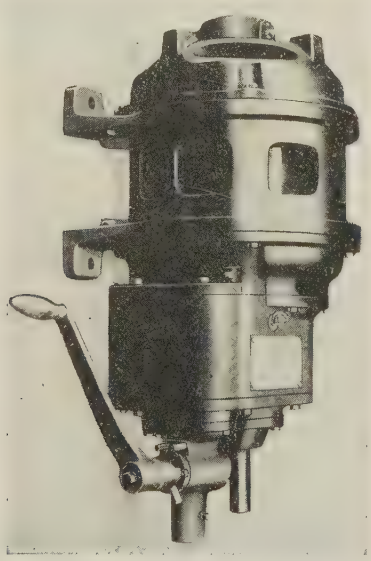

Fig. 6—Motor with Built-In Four-Speed Transmission Showing Speed Changing Lever

connected to their lines during the year. This represents an increase of 16 per cent over the total number previously connected. This growth is accounted for partly by the interest of the power companies in the farm load and partly by improved rate structures and power schedules. But of fully as great importance however is the increasing list of electrical equipment which is available and specially adapted for farm service. The attention being given to the production of milk with a low bacteria count has done much to force the installation of dairy sterilizing and dairy refrigerating equipment and these devices in connection with other dairy and household equipment make a very desirable electrical load.

Engineering research and investigation have proven the possibility of using 5-hp. electric motors for practically all stationary work such as silo filling, feed grinding, wood sawing, etc., instead of using 15- or 20-hp. tractors. Numerous improvements have recently been made in the design and construction of portable motor equipment for such service which includes automatic linestarters with thermal overload protection, effective methods of belt tightening, and other desirable features.

Food Products Industry

Although this industry has received but little attention from electrical engineers, it is the fourth greatest user of electric motors on the basis of connected horse-

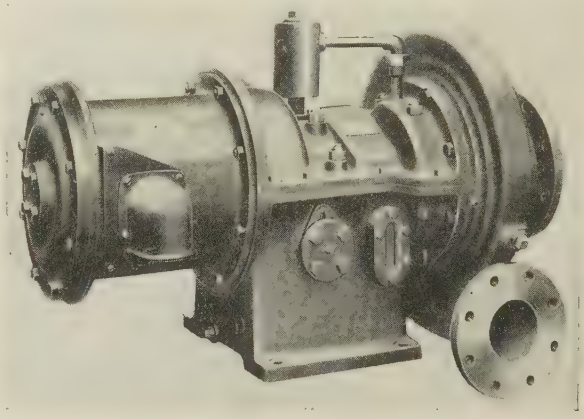

Fig. 7—Geared Centrifugal Refrigeration Compressor Driven by Totally-Enclosed Induction Motor

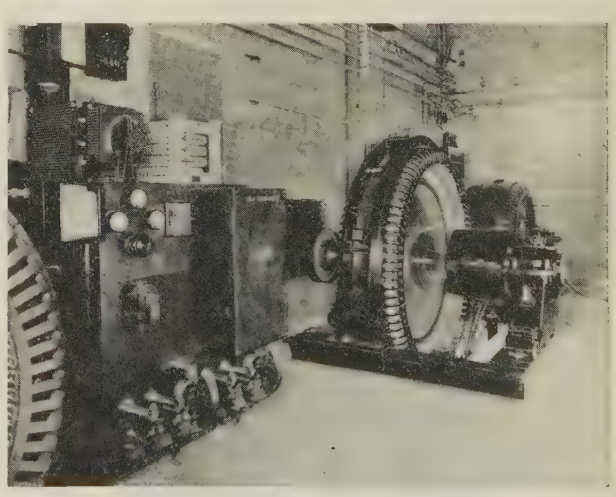

Fig. 8—300-Hp. 164-Rev. per Min. Synchronous Motor of the Phase-Connected Damper Type as Installed in a Cement Plant

power. In addition to motors, electric energy is used for various other purposes as the production of ultra-violet rays to help preserve or increase the vitamin content of foods; photoelectric tubes for actuating operations of wrapping, sorting, and counting; cooking of foods by various electrical processes, and the pasteurization of milk.

A paper on the subject of *A Modern Electrified Dairy Plant* was presented at the Pittsburgh District Meeting of the Institute March 11-13, 1931, by Mr. A. J. Dreux and Mr. H. C. Brunner. This paper

illustrates how a modern electrified dairy offers a very desirable type of load for central stations, particularly when using the electrical conductivity method of pasteurization.

Induction and D-C. Motors

During the past year several new lines of induction motors have been placed on the market and the trend is toward simplification and standardization of design. The greater use of standardized parts reduces the stocks which must be carried both by the user and manufacturer, increases the number of combinations or types of motors possible with a given number of parts and in general makes the apparatus more universally adaptable.

Several new lines of totally enclosed fan-cooled squirrel-cage induction motors have been announced and in practically all cases these motors are on the same frame size as corresponding ratings of open motors. In these fan-cooled motors ball or roller bearings are used almost without exception and the cartridge type of bearing housing is quite generally adopted. This construction permits the dismantling of the motor and the removal of the rotor without exposing the bearings.

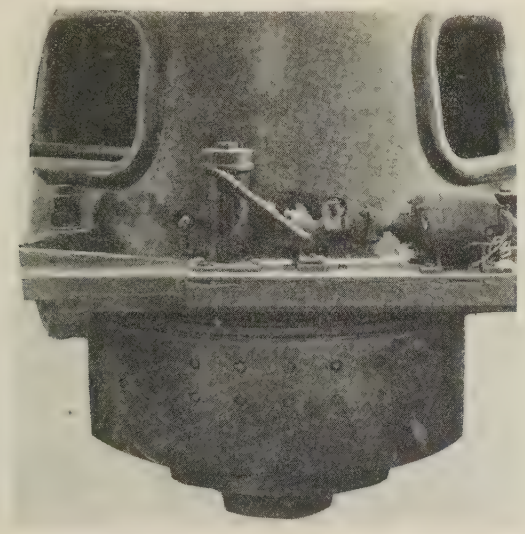

Fig. 9—Special Synchronous Motor with External Revolving Field, Direct Connected to Gyratory Crusher

A number of manufacturers has also brought out lines of totally enclosed fan-cooled motors for use in locations where explosive gases are present. These motors are approved by the Underwriters Laboratory for use in gasoline refining, garages, gasoline handling, and filling stations, dry cleaning establishments, chemical plants, paint factories, and in similar locations.

To meet the requirements of testing large vertical pumps and turbine wheels a vertical dynamometer rated at 300 hp. has been developed. The stator is supported in such a manner that it is free to rotate and the torque developed is measured on a beam and dial scale. The direct-current armature is especially constructed and makes use of a shrink-ring type commutator for high-speed operation.

Fractional horsepower motors of the universal commutator type have a wide speed range from no load to full load and consequently are not generally applicable for the constant speed service. A novel type of clutch has been developed which when installed in these fractional horsepower motors maintains a practically constant speed at the coupling regardless of how much higher the motor speed may go. This device consequently makes it possible to use universal motors for such applications as cash registers, calculating machines, small motor-generator sets, etc.

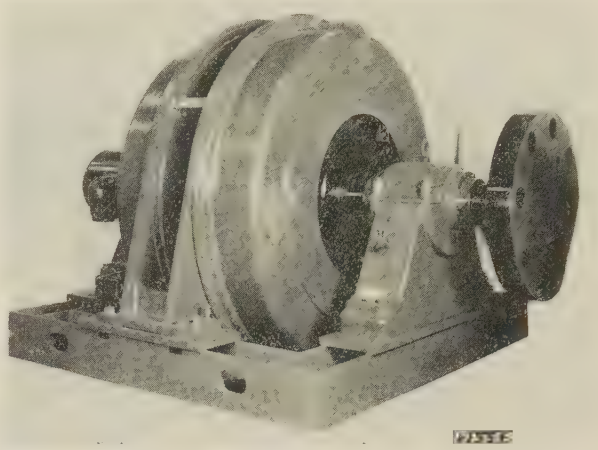

Fig. 10—250-Hp., 450-Rev. per Min. Totally-Enclosed Fan-Cooled, Synchronous Motor

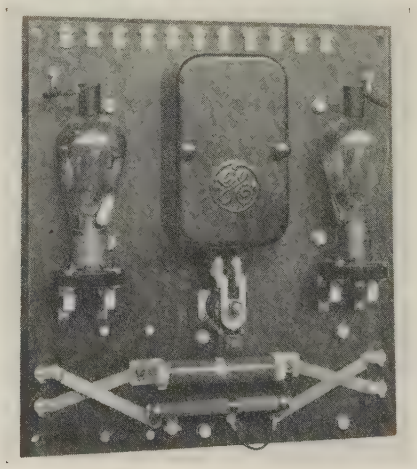

Fig. 11—Electronic Tube Control for Small D-C. Motors

Although speed reducers or gear reducers are now extensively used there is a decided trend towards the combination of various types of these gear reducers with industrial motors in order to form a more compact and self-contained unit. Some of these are of the fixed ratio type with either single, double, or triple reduction while

others have a variable ratio. A recent addition consists of a standard constant speed motor in combination with a 4-speed gear forming a self-contained and very compact unit. With this combination various gear ratios are available and it is possible to change from one speed to another under full load conditions.

Another example of a combined unit is a centrifugal type compressor for refrigerating service in which the compressor, gears, and motor are combined in one unit.

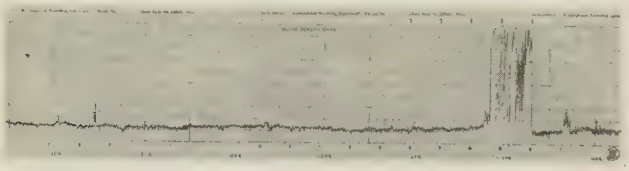

Fig. 12—Sample Chart Obtained with Smoke Recorder

This is a high-speed single-stage compressor of approximately 25 tons refrigeration capacity and by means of the unit type construction it is possible to eliminate the usual shaft seals.

A paper presented by Mr. A. M. Rossman at the Philadelphia meeting *A New System of Speed Control for A-C. Motors,* gives a detailed account of a new method of speed control, its possibilities, and savings. The system consists essentially of a constant speed a-c.

Fig. 13—Console Type Board for Electronic Tube Control of Theater Lighting and Dimming

motor of either the synchronous or induction type, supplemented by an adjustable speed d-c. machine of much smaller size and a motor-generator set of similar capacity. The frame of the a-c. motor is mounted on bearings so that the frame as well as the rotor may rotate.

Synchronous Motors

At the Winter Convention two papers on the subject of synchronous motors were presented. The motor described by Mr. M. A. Hyde, Jr., was developed especially for low-speed applications requiring high starting and high pull-in torques with a low-current inrush. The damper construction instead of being of the usual squirrel-cage type is phase wound and in starting an external resistance is inserted in this circuit and the motor accelerates in a manner quite similar to that of the ordinary wound rotor induction motor.

The paper presented by Messrs. McLenegan and Ferriss discusses the design features of normal synchronous motors and shows how these features are varied to adapt synchronous motors to the requirements of various special applications. Among the various modifications discussed are the use of part-winding starting for applications where low-starting torques and low-starting inrush are desirable, also various methods of obtaining high-starting torque such as by means of over-sized motors, over-voltage, delta-Y starting,

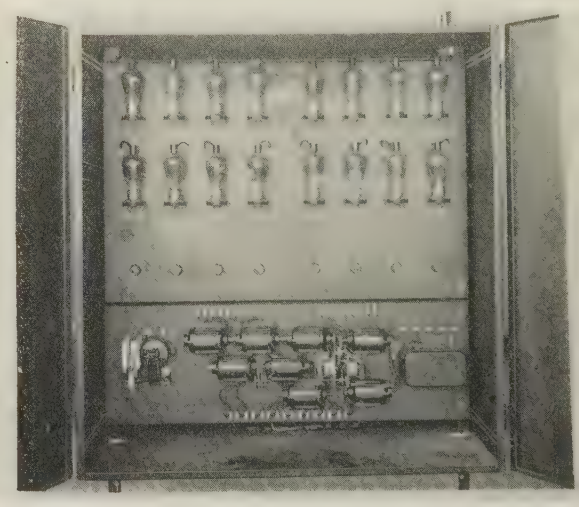

Fig. 14—Electronic Tube Control of Polychromatic Flood-Lighting System

tapped windings, phase-connected damper windings for both salient and non-salient pole motors, and a rotable stator scheme.

It is reported that the first application of a synchronous motor directly connected to a grain elevator leg was made during 1930. Ordinarily the starting torque required by these legs or bucket elevators is comparatively light but in case of emergency such as starting after a power failure, with the buckets loaded, a high-starting torque and a high pull-in torque are required.

Although several high-torque synchronous motors have been applied to primary or large gyratory crushers most of these have been of the standard mechanical construction and usually belted to the crusher pulley. A unique application has been made which utilizes a vertical motor of the umbrella type in which the revolving field poles are external to the stator which in turn is bolted rigidly to the frame of the crusher.

Another interesting and rather unusual application of a synchronous motor is for driving a hot copper rolling mill which requires continuous reversing service. The motor is guaranteed to reverse in five seconds and a special type of damper winding construction is used to increase the radiating surface and dissipate heat caused by the frequent starting and stopping.

For use in the Chilean Nitrate Industry a number of synchronous motors rated at 250 hp., 450 r. p. m., was built of the totally enclosed fan-cooled type. This construction is necessary to protect the motors against the saline solutions and vapors and the construction details are along very much the same lines as carried out on the smaller industrial motors.

When protected type motors are required either on account of injurious vapors or dust, it is sometimes undesirable or impossible to locate the control equipment in separate rooms and to take care of those cases

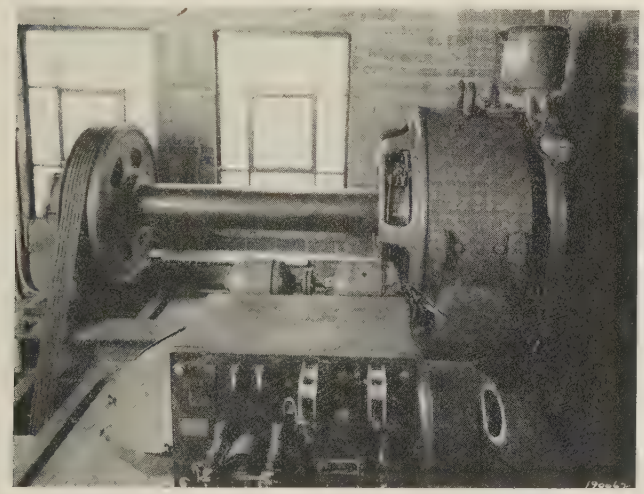

Fig. 15—Motor for Lower Elevator of Dual System with Combination Motor-Generator Set and Control Foreground

in which the control must be mounted in the same location as the motor, synchronous motor starters have been developed with the entire control immersed in a tank of oil.

Electronic Tubes

During the past year the electronic tube has become an accepted industrial device. Its original use was confined to the arts of communication and science and not until recently has any concerted effort been made to apply it to industrial purposes. Electronic tubes possess characteristics not available in older forms of electrical apparatus but offer many possibilities for industrial applications. These characteristics may be listed briefly as follows: speed of operation, small actuating energy requirement, amplification properties, accurate response, quietness of operation, and freedom from moving parts and contacts. In addition, the actuation of electronic tubes may be brought about by a large number of different physical effects including changes in resistance, inductance, capacitance, phase angle, frequency, temperature, sound, light, color, radio or carrier current.

There has developed a demand for electronic tube units which can be adapted to many applications for experimental purposes. Such units have been brought out by several manufacturers. The more common of these are the photoelectric units and electrostatically controlled arc discharge units. The tubes used in the latter are better known by the trade names of grid glow or thyratron.

In line with this increasing interest a paper entitled *Electron Tubes in Industry*, was presented by Mr. W. R. King at the Winter Convention. This paper gives a general discussion of the theory and characteristics of electron tubes without going into design details or calculations. Several of the more common control schemes involving tubes are explained for the purpose of showing how tube characteristics can be adapted to various applications.

To eliminate the human element in determination of smoke density a device utilizing a light source and photoelectric tube in connection with a recording instrument has been developed and gives a continuous accurate record of smoke density. The light source is mounted on one side of the stack and throws a beam of light through an aperture on the photoelectric tube mounted on the opposite side. The amount of light reaching the photoelectric tube is determined by the smoke density, and indicating or recording instruments may be installed at any convenient location.

One of the most interesting and largest electron tube applications is the control of lighting for stages and auditoriums. Installations of this type involve the use of between 300 and 600 electron tubes. Three installations of this type are in the Civic Opera House in Chicago, the Severance Memorial Hall in Cleveland, and a theatre in Los Angeles. The latest of these units, the one at Cleveland, has all of the control circuits operated from an organ type console. With this control it is possible to pre-set scenes, gradually fade from scene to scene with either manual control or automatically at a pre-determined rate, and vary the intensity of any light circuit in the hall individually or in combination with any other circuit or circuits. In the old types of stage lighting control the intensity was varied by means of rheostats. This new method uses three-legged reactors located conveniently for load distribution and the degree of saturation and consequent change in light intensity is varied by rectified direct current from tubes. Another application for the same type of equipment as used for theatre dimming is the control of building flood lights. On a large number of new buildings the lighting is so arranged that the shading and colors vary in some regular cycle.

Electron tubes are also being used for speed control

of d-c. motors in a number of various applications. At the present time for smaller motors, that is 3 hp. or below the control can be accomplished directly by control of armature voltage and current supplied from tubes, while for larger motors the field current only is controlled and supplied by tubes. One of the better known applications of this type is the maintaining of proper tension in the wire for a wire drawing machine and reel.

Photoelectric units have also been adapted to any number of production line applications where the objects are too light or fragile to operate ordinary control making or breaking devices by physical contact. On any application where an object can be made to intercept or otherwise vary a light beam this action can be used to actuate an operation. Some of the more common applications have been for counting, wrapping of packages such as foods, gum, etc., flag switches for reversing rolls as in steel mills, flashover protection of rotary converters, cutting of paper sheets to the proper length as required in connection with paper bag machines, paper break indicators in connection with paper machines, turning on and off lights in factories or offices to give proper illumination without wasting of power, and determining the transparency of paper.

Elevator Equipment

During the past year numerous improvements and refinements in elevator electrical equipment were made in keeping with the tendency toward higher speeds, automatic landing control, and quieter operation. The common trend toward combination units is also illustrated in elevator apparatus by building of motor-generator sets with exciter and control in one frame.

One of the completely new and interesting developments of the past year was the building of an elevator with two cars operating in one shaftway. Obviously the object of this arrangement is the saving of floor space in tall buildings where the space occupied by elevator shaftways is both valuable and large, inasmuch as the shaftway area must be subtracted from each floor. This elevator embodies all of the latest features in elevator design including automatic floor landing, door opening, and futuristically decorated cars. The cars use the floor bottom system of control and in addition a set of signals are displayed in each car indicating the relative position of both cars in the shaftway. The cars are prevented from approaching each other closer than two floors by an automatic block system of control which brings the car to a normal stop when this limiting distance is reached.

Conclusion

The Committee feels that there is a large field open for the electrical engineer in industry and that the Institute can be of material assistance to its members by bringing before them the important developments and trends in the various industries. In the preparation of this report we desire to acknowledge the assistance given by the various members of the committee and also by the Electric Machinery Manufacturing Co.

Instruments and Measurements

ANNUAL REPORT OF COMMITTEE ON INSTRUMENTS AND MEASUREMENTS*

THE Committee on Instruments and Measurements has been active during the past year on the following subjects:

1. Standard definitions for telemetering.
2. Standards for recording instruments.
3. Standards for indicating instruments.
4. Revision of Standards No. 14—Instrument Transformers.
5. Revision of Electrical Units.
6. Symposium on precision measurements.
7. Technique of temperature measurements.
8. Measurement of reactive power.
9. Method of measuring distortion factor.
10. Review of proposed papers.
11. Conclusion.

Standard Definitions for Telemetering

The subcommittee devoted to telemetering has been active for a number of years. Last year in this report there were published for comment standard definitions on this relatively new subject. It has been felt that, with the interest in the field of telemetering, it would be desirable to have some standard definitions so that the terms which are used would not be results from a hit and miss selection, as often occurs in newly developed fields. With comments received this year a set of standard definitions was approved by the membership of the Instruments and Measurements Committee, and is now ready for transmittal to the Standards Committee for adoption.

Standards for Recording Instruments

As a result of several years work, a subcommittee has completed a draft of proposed standards for recording instruments. These standards have been approved by the Instruments and Measurements Committee, and are now ready for submission to the Standards Committee.

The work of the subcommittee is under the chairmanship of Mr. Kinnard. A large amount of work has been involved in the development of these standards so as to cover this field of measuring instruments. The Committee has considered many new items which have shown that the Standards for Indicating Instruments should also be revised.

Standards for Indicating Instruments

Since 1927, Instrument Standards No. 23 has been used by the industry. Since that time considerable progress has been made, and experience with the Standards has indicated that a revision would be desirable. A subcommittee was appointed at the beginning of this year to start the revision.

Revision of Standards No. 14—Instrument Transformers

A subcommittee has been active during the past year revising Standards No. 14 covering instrument transformers. This standard was approved in 1925. It was the feeling of the members of the Instruments and Measurements Committee that progress in the art warranted revision at this time. The committee is under the chairmanship of Mr. Gibbs. Several tentative drafts have been prepared and revised so that these standards will soon be in form to be submitted to the Committee membership for approval.

Revision of Electrical Units

The report of the Committee on Instruments and Measurements for the Institute year ending July 31, 1929, contained a brief account of the participation of this Committee in the events which led up to the first meeting of the (international) Advisory Committee on Electricity at Paris in 1928. At that meeting resolutions of far-reaching importance were adopted, to the effect that the absolute system of electrical units, derived from the c. g. s. system, may be substituted with advantage for the present international system of units which is based upon arbitrary legalized material standards, namely, the mercury ohm and the silver voltameter.

The second meeting of the Advisory Committee on Electricity was held in Paris in June 1930. The American representative on the Committee, Dr. G. K. Burgess, Director of the Bureau of Standards, was prevented from attending, and sent Dr. H. B. Brooks as his substitute.

Representatives were sent by the national standardizing laboratories of England, Germany, Japan, and the Soviet Republics; by the Laboratoire Central d'Electricite of Paris, and the International Bureau of Weights

*COMMITTEE ON INSTRUMENTS AND MEASUREMENTS:

E. J. Rutan, Chairman,

H. S. Baker,	M. Eppley,	H. C. Koenig,
P. A. Borden,	R. C. Fryer,	W. B. Kouwenhoven,
H. B. Brooks,	J. B. Gibbs,	F. A. Laws,
O. J. Bushnell,	W. N. Goodwin, Jr.,	E. S. Lee,
A. L. Cook,	I. F. Kinnard,	Paul MacGahan,
E. D. Doyle,	O. A. Knopp,	R. T. Pierce,
Melville Eastham,	A. E. Knowlton,	W. J. Shackelton.

and Measures at Sevres. Italy was represented by Professor L. Lombardi of the Royal School of Engineers at Rome. Other experts were present as invited guests. A large part of the sessions was taken up with the discussion of a new duty which the International Committee of Weights and Measures had recently laid upon the Advisory Committee on Electricity, namely, that of advising the International Committee on all questions relating to the methods of measurement and to the units and standards of light.

Concerning the primary standard of light, resolutions were adopted supporting the view that a black-body radiator should be adopted; requesting the national laboratories to examine the specifications for the Waidner-Burgess primary standard of light and to give their views regarding the practicability of its adoption; and urging the desirability of making additional determinations of the brightness of the black-body radiator, especially under the conditions prescribed by the Bureau of Standards' specifications, or at least under conditions comparable with them.

Concerning the unit of light and its maintenance, the Advisory Committee adopted a resolution to the effect that it is inexpedient to change the unit (*i. e.*, the international candle) which has been in use since 1909. Other resolutions adopted relate to the exchange and comparison of groups of lamps by the national standardizing laboratories, and to the adjustment of the values of the practical secondary standards, as may be necessary in the future as a result of reference to a primary standard.

Concerning the electrical units and standards, two resolutions were adopted, as follows:

1. With regard to the unit of resistance, the ohm, considering that methods of determining the absolute ohm are sufficiently advanced and that the agreement between the measurements of the coils (secondary standards) of the different laboratories remains within the limits of precision of the measurements, it is not necessary at present to undertake further comparisons of the resistance coils with mercury ohms.

2. As to the units of electromotive force, on the contrary, the international comparisons of standard cells show differences, exceeding the limits of possible precision, between the values of the electromotive force of the standards of different countries. The committee considers that it is absolutely necessary to make new determinations of the electromotive force of the international Weston cells in each national laboratory by means of the silver voltameter.

The conditions under which the silver voltameter should be used are specified sufficiently in the report of the international committee which met in Washington in 1910. The Advisory Committee recommends, however, that the national laboratories use the Smith or the Kohlrausch voltameter, avoiding organic material, which is detrimental to the electrolytic deposit.

The groups of Weston cells prepared in the several laboratories can be considered as sufficiently constant until the absolute unit of current shall be established.

It should be noted that these recommendations concerning standard cells and voltameters do not in any way modify the Advisory Committee's recommendation of 1928 looking to the ultimate legalization of the absolute ohm, volt, and ampere on a basis free from all arbitrary character. The recommendations merely recognize that the standard cell and the silver voltameter are useful tools, when properly used, and are essential to the maintenance and dissemination of the international electrical units under the existing limitations.

The Advisory Committee also made recommendations regarding the equipment of the International Bureau of Weights and Measures and plans for cooperation between that bureau and the national laboratories in work on electric and photometric standards. Since an international General Conference on Weights and Measures is to be held in 1933, the Advisory Committee decided that it should meet again before that time to study the comparisons of standards which shall have been made and to assign values in absolute units for the standards of resistance and of electromotive force.

Symposium of Precision Measurements

In view of the recent activity of the International Advisory Committee on Electricity, it was felt desirable to have some outstanding papers written concerning the fundamental electrical units. The subject is being treated in a symposium which is being presented at the 1931 Summer Convention and which includes four papers. These are:

1. *International Standard of Electromotive Force and Its Low-Temperature Coefficient Form*, by Marion Eppley, the Eppley Laboratory, Inc.
2. *The Unit of Electrical Resistance; Past History and Impending Change*, by H. B. Brooks, National Bureau of Standards.
3. *Design of Potentiometers*, by I. Melville Stein, Leeds and Northrup Company.
4. *Electrical Units and Their Application*, by L. T. Robinson, General Electric Company.

Technique of Temperature Measurements

In order to set up a standard code for temperature measurements, a subcommittee has been appointed. This committee has already analyzed all of the temperature requirements included in the various standards of the Institute, and is now summarizing these data preparatory to setting up the necessary measurement technique.

Measurement of Reactive Power

Considerable interest is being displayed in the matter of measurement of reactive power. A subcommittee has been considering this subject, and is cooperating with a committee appointed by the

Standards Committee under the chairmanship of Mr. A. E. Knowlton.

Method of Measuring Distortion Factor

In line with the recommendation of this Committee, made in last year's annual report, a subcommittee has been following the performance of Belfils Bridge which is being used by one of the manufacturing companies. The work has progressed to the point where a report has been prepared covering the performance of this apparatus. At the present time the report is in circulation among the members of the Instruments and Measurements Committee in order that their comments and recommendations may be obtained in regard to the suitability of this device for the measurement of distortion factor.

Papers

In addition to the four papers mentioned above in connection with the symposium of precision measurements, nine papers have been submitted to this Committee for review. Some of these have already been approved for publication and presentation and the remainder are in circulation and will be reported on shortly. These papers are listed below:

Measurements of Cable Insulation Characteristics

A High-Sensitive Power-Factor Bridge, by W. B. Kouwenhoven and A. Banos.

High-Voltage Bridge for Measurement of Cables with Grounded Sheaths, by C. F. Dawes and A. F. Daniel.

The Elimination of an Inherent Error in the Usual Form of Capacitance Bridge for Capacitance and Power-Factor Measurements by the Substitution Method, by R. P. Siskind.

Measurements of Magnetic Flux

Core Loss Measurements at High-Flux Densities, by B. M. Smith and C. Concordia.

This paper was presented at the Northeastern District Meeting, Rochester, N. Y., April 1931.

Miscellaneous Subjects

A Direct-Current Bushing Transformer, by A. S. Fitzgerald.

A New Overcurrent Relay with Straight Line Characteristics, by S. L. Goldsborough and R. M. Smith.

A Thermionic Type Automatic Synchronizer, by F. H. Gulliksen.

The Characteristics of the Oscillograph-Galvanometer, by V. S. Thomander.

The Amplifier-Oscillograph, by S. K. Waldorf.

Conclusion

Active interest has been shown by the members of the Committee on Instruments and Measurements through the year. The meetings held were well attended and subcommittee reports indicated considerable progress was being made in each of the assigned activities, and definite steps have been taken on several as indicated above. During the coming year it is expected to complete some of the other projects.

Applications to Iron and Steel Production

ANNUAL REPORT OF THE COMMITTEE ON APPLICATIONS TO IRON AND STEEL PRODUCTION*

THE functions of this committee have, in the past, been largely confined to (1) encouraging the presentation of papers before the Institute dealing with those phases of electrical engineering which are major factors in the utilization of electricity in the steel industry. (2) To preparing an annual report which briefly summarizes such phases of the application of electricity to the production of iron and steel as are considered new or of special interest to the membership.

During the past year, the committee's work has followed the previous precedent, in procuring papers. It also actively cooperated in arranging a joint session of the Institute with the Association of Iron and Steel Electrical Engineers at the meeting of the Middle Eastern District held in Pittsburgh on March 11th to 13th inclusive, 1931. The papers presented before this meeting which the members of this committee were active in procuring are as follows:

1. "Conversion and Distribution of General Purpose D-C. Power in Large Industrial Plants," by R. D. Abbiss, Carnegie Steel Co., and D. C. West, Westinghouse Elec. & Mfg. Co.

2. Symposium on Interconnection Between Utilities and Industries: Davison Coke and Iron Co. and Duquesne Light Co. Interconnection, by G. E. Dignan, Davison Coal and Iron Co. and R. L. Kirk, Duquesne Light Co.

3. "Interconnection of Power Supply Between Public Utilities and Large Industrial Users," by F. O. Schnure, Bethlehem Steel Co.

4. "Absorption of By-Product Power," by A. Hoeffle, Toledo Edison Co. and W. T. Woodmancy, Interlake Iron Corp.

5. "The Use of Electricity in Large Annealing Furnaces," by J. C. Woodson, Westinghouse Elec. & Mfg. Co.

The Committee wishes to report that this joint meeting of the Institute and the Association of Iron and Steel Electrical Engineers was a very successful part of the Middle Eastern District Meeting Program, and suggests that joint meetings with the Association of Iron and Steel Electrical Engineers be encouraged in the future.

*COMMITTEE ON APPLICATIONS TO IRON AND STEEL PRODUCTION:

A. C. Cummins, Chairman,
F. B. Crosby, A. G. Pierce, G. E. Stoltz,
M. M. Fowler, F. O. Schnure, Wilfred Sykes,
S. L. Henderson, W. B. Shirk, T. S. Towle,
A. M. MacCutcheon, H. A. Winne.

Electrical Developments in the Iron and Steel Industry During 1930

During the year 1930 there has been a general recession from the unusually high operating rates of the preceding year, and an accompanying reduction in expenditure for improvements and new plant facilities. However, an impressive amount of electrical equipment has been purchased and many interesting developments have taken place. Undoubtedly, the very successful electrification of rolling mills and their auxiliaries has been an important factor in the steel industry.

The iron and steel industry during 1930, purchased 163,490 total horsepower of main drive motors, rated 300 hp. or over, as compared to a total of approximately 350,000 hp. during 1929. The fact that the rate of increase in installed horsepower for main drives is greater than the rate of increase for ingot capacity, indicates the tendency to modernize old mills.

Direct Current Motors

Many important installations have been completed during 1930, with others rapidly nearing completion. From various viewpoints, a new 10,000-hp., 54-inch blooming mill in the Chicago District is memorable. It is the most powerful mill yet installed by a margin of 2,000 hp., an increase in power which will be useful in rolling thicker and heavier sections. This tends toward greater output of the whole plant, the blooming mill being the first of all the rolling operations.

Even more than for its size, this mill is unique in that the two main rolls, usually geared together, are driven individually, each by its own motor. This is a great improvement over the former method of a single motor coupled to a pinion stand. The ordinary construction of mill pinions and housings permits wear and misalinement from which develop accelerated wear, noise, vibration, and occasional breakage. Often the mill must continue in operation for several days after trouble has been developed before it can be conveniently shut down.

Each roll of the new 54-inch mill is driven by a double armature motor rated at 5,000 hp., 700 volts, direct current, at 40/80 r. p. m., both motors being under electrical control which keeps the speed of the two rolls precisely the same. The torque developed is 4,000,000 lb-ft., from standstill up to normal speed. The motors are of minimum diameter to avoid angularity of the

mill spindles between motor and rolls, an incidental advantage being smaller inertia.

Immediately following the 54-inch blooming mill just referred to is the 52-inch beam mill. The roughing mill is driven by a 7,000-hp. reversing motor, and a 2,000-hp. reversing motor for the edging stand. Likewise the intermediate mill will be equipped with reversing motors rated at 6,000 hp. and 2,000 hp.

There is now under construction by this same company, a 44-inch universal slabbing mill, the driving motors of which will have a continuous capacity of 12,500 hp., and a maximum emergency capacity of 35,000 hp. The upper and lower horizontal rolls are to be individually driven by two 5,000-hp., 40/80-r. p. m. reversing motors, constituting a twin motor drive of 10,000 hp., 4,000,000 lb-ft. maximum torque capacity, duplicate of the 54-inch blooming mill now in operation. The vertical edging rolls are to be driven by a third reversing motor, rated 2,500 hp., 79/225 r. p. m., 500,000 lb-ft. maximum torque capacity. Power for the three reversing motors will be furnished by a 10,500-kw. flywheel motor-generator set consisting of a 180,000-lb. flywheel, a 6,500-hp., 25-cycle, 6,600-volt, 370-r. p. m. induction motor, and three 3,500-kw., 700-volt generators connected in parallel. This installation will be of unusual interest to steel mill engineers because of the large size of the mill and the electrical equipment, and also because of the method of drive, utilizing three reversing motors with control to provide adjustment of relative speeds, thus permitting variations in drafting and the use of rolls of unequal diameter.

To secure the necessary refinement for the accurate automatic control of the screwdown mechanisms on a 32-inch three-high universal plate mill and on roughing and intermediate 52-inch universal structural mills, seven variable-voltage screwdown equipments have been installed. The variable-voltage control permits much more accurate settings than could be obtained with rheostatic control, either automatic or manually operated, and thus speeds up the operation of the entire mill. A further advantage is the elimination of the large capacity reversing and accelerating contacts and starting resistor, with accompanying lowered maintenance.

In addition to the 54-inch and 44-inch mills referred to above, this company is also completing a 96-inch continuous plate mill, a 10-inch alloy bar mill, a large open-hearth department, and a 20,000-kw. addition to the existing steam turbine power station.

The 10-inch alloy bar mill will be driven by nine direct current motors, totaling 7,627 hp. Some of the motors have a speed range of approximately 5 to 1, which is obtained partly by motor field adjustments and partly by armature voltage control through the use of auxiliary bucking generators, one for each of two motors which have this large speed range. The use of these bucking generators permits operating the three main 1,750-kw., 600-volt generators in parallel at constant bus voltage. The motors will be equipped throughout with speed regulators of the vibrating type, designed to hold the speed regulation within very close limits.

An 8,000-hp., 40/100-r. p. m. reversing motor is now being built to drive a 44-inch blooming mill at Gary. This motor will be capable of developing a maximum torque of 2,900,000 lb-ft. The mechanical parts of this motor, including the armature spider, will be of fabricated steel construction throughout. Several reversing motors with fabricated and electrically welded armature spiders have been in service for some time, demonstrating beyond doubt the reliability of this type of construction. Power for the 8,000-hp. motor will be supplied by a 375-r. p. m. motor-generator set, consisting of two 3,500-kw. generators, one 6,000-hp., 6,600-volt, 25-cycle induction motor, and one 200,000-hp-sec. flywheel.

A southern steel company has placed in operation at Alabama City, a new 40-inch blooming mill which replaces an engine-driven 36-inch mill. The 40-inch mill is driven by a 7,000-hp., 700-volt, 50/120-r. p. m., single-armature reversing motor supplied with power from a 6,000-kw. flywheel motor-generator set. This company has also installed a new 32-inch three-high universal plate mill driven by a 4,000-hp., 80/160-r. p. m., d-c. motor, similar to a reversing mill motor, with variable-voltage power supplied by a 3,200-kw. flywheel motor-generator. The major part of the mill output is light gage sheets. The type of drive used permits the operator conveniently to select low speeds for the roughing passes, and high speeds for the finishing passes, with very rapid acceleration to the desired rolling speeds. An important feature of this mill is the automatic screwdown. When the operator moves the pass master switch to each successive position, the desired screwdown setting for each pass is obtained by automatic control.

A 20-inch continuous hot strip mill in the Detroit District was put into operation in 1930. This mill has ten stands, each driven by an individual d-c motor. The drive for this mill has one very interesting feature. When rolling from slabs of such length that the piece will reach from stand 4 to stand 5, the section of the bus to which the first four motors and one 5,000-kw. generator set are connected, is segregated from the bus to which the remainder of the motors and the other generators are connected. This is necessary because the minimum speeds of the first four motors when operating at normal rated voltage are such that the metal would be delivered from stand 4 at a very much higher speed than it enters stand 5. Consequently, when the piece is continuous between stands 4 and 5, the speeds of the first four stands must be lowered by reducing the voltage of the generators on the section of bus to which the first four motors are connected. A similar arrangement was incorporated in the control of the first two motors on the 60-inch strip mill in a plant at Steubenville, Ohio.

Motor drive has for the first time been successfully applied on a large scale to the operation of a 900-ton ingot pressing application that was formerly monopolized almost entirely by steam or hydraulic operation. This press is in the new plant of a wrought iron manufacturer near the Pittsburgh District and compresses wrought iron sponge balls, about five feet in diameter, into rectangular ingots, measuring about 6 ft. by 18 inches square, preparatory to rolling in the blooming mill. On the final squeeze, it is necessary to exert a pressure of at least 1,000 pounds per square inch. Maintenance of factory production at full speed, requires operating the rams up to 75 feet per minute. Still the motors and press must be protected from the enormous stress which would result if the ram was brought up suddenly against a solidly compressed ingot. The solution of these and other problems involved a coordination of generator, exciter, and motor characteristics with manual and automatic control facilities, so that, as the pressure increases, the ram speed is slowed up towards the end of its stroke and the current will never exceed the allowable limit.

The main 900-ton ram is driven, through four racks and eight pinions, by a double-armature, 1,200-hp., d-c. reversing motor, having a normal full-load speed of about 125 r. p. m., and a maximum light-load speed of 275 r. p. m. The motor was built with two armatures in order to reduce the $W R^2$ and to halve the current to be carried by each commutator. The auxiliary 200-ton end rams are driven by a 325-hp. single-armature motor, having a nominal full-load speed of 250 r. p. m. and a maximum light-load speed of 550 r. p. m. The motors are of sturdy mechanical construction, with cast steel armature spiders, special armature coil bracing, and thrust bearings at the coupling end. Rear enclosing end bells are provided so that the motors may be ventilated. This is necessary as the motors carry heavy loads at very low speeds, and are therefore incapable of self-ventilation.

Variable-voltage d-c. power for the two press motors is furnished by a four-unit synchronous motor-generator set, consisting of a 1,000-kw. generator for the large motor, a 300-kw. generator for the small motor, a 1,500-hp., 80 per cent power factor, 6,600-volt, three-phase, 60-cycle, synchronous driving motor, and a 50-kw., 250-volt exciter.

In addition to the electrical features enumerated, the mechanical design of the press incorporates a number of features intended to provide safe and reliable operation. The faces of the main ram head and stationary side stop are not smooth but have corrugations vertically and horizontally across them, so that on the first impact, only about 10 per cent of the total face of the ram strikes the ingot and the ram has to move in about 1½ inches before the entire face strikes.

The electrically driven press has been in operation several months, and its success has demonstrated the practicability of electrical drive for such machines.

A mill in the Youngstown District has purchased the electrical equipment for a 10-inch bar mill having 12 tandem stands. Ten d-c. motors totaling 7,350 hp. with variable-voltage control from two 2,000-kw. motor-generator sets will be used with this mill. The mill will have two unique features, one being the method of speed control and the other is the use of vertical motors to drive the vertical roll main stands.

A speed regulator of the carbon pile type is used with each motor and with a master frequency generator to maintain a desired speed relation between stands. The customary bevel gear drive to the rolls has been eliminated by the use of vertical motors. The vertical motor is mounted above the mill on an overhung support. This support also carries the rolls and pinion housing. The rolls can be moved sideways or up and down with respect to the bar being rolled so that the vertical rolls can be lined up with the grooves of the horizontal rolls.

Synchronous Motors

Among the more important synchronous motors which have been purchased during the year may be mentioned two 4,500-hp., 156.5-r. p. m., 6,600-volt, 60-cycle units which will drive two rolling mills in the plant of a Pennsylvania manufacturer. This company also purchased one 5,000-hp., 360-r. p. m., 6,600-volt synchronous motor to drive a 24-inch billet mill and one 4,000-hp., 360-r. p. m., 6,600-volt motor to drive a 28-inch billet mill at the same plant early this year. This company put into operation a 3,000-hp., 100-r. p. m., 11,000-volt, three-phase, 60-cycle synchronous motor, driving a three-high billet mill. This motor is of interest not only because it is one of the few main roll motors operating at over 6,600 volts, but also because it is started directly from the 11,000-volt circuit.

A West Virginia manufacturer has purchased two synchronous motors, one 2,000-hp., 300-r. p. m. and one 1,000-hp., 360-r. p. m., which will drive the hot tin mills. This is believed to be the first installation of synchronous motors on mills of this character, previous practise having been to use induction motors with flywheels. Synchronous motors were chosen because of the necessity of maintaining a good power factor, and also because of the gain in efficiency. Not only is the synchronous motor itself more efficient than the corresponding induction motor, but the friction and windage losses of the usual flywheel and the power losses in the secondary resistor or liquid slip regulator are eliminated. It is estimated that the power per ton of tin plate rolled will be at least 5 to 10 per cent less than if an induction motor flywheel drive had been used.

Switchgear

All the modern improvements in switchgear equipment are rapidly being adopted by the iron and steel industry. The metal clad type of switchgear with its

ve parts completely enclosed, excluding dust and irt and at the same time protecting the operator from ossible injury, is ideally suited to steel mill service.

Auxiliaries

Automatic screwdown equipment has been developed o the point where it will rapidly become more generally sed. Two recent applications, one in a universal late mill and the other in a structural mill have been ientioned in this article. The use of variable-voltage quipment for these screwdown drives has proved ery desirable.

There is increasing industrial activity in the applica- ion of vacuum tubes and related devices. The crane perator on the soaking pit cranes for a 54-inch mill in he Chicago District will control the opening and losing of the soaking pit covers through the action of hotoelectric cells. In another plant, a photoelectric ell acts as a "flag" switch to make the necessary set-up or registering the temperature of each billet as it pproaches the rail mill. Undoubtedly, the field for uch applications will rapidly increase.

The majority of the motor-driven heavy shears, uch as bloom and slab shears, which are now in opera- ion, are driven through clutches by induction motors quipped with flywheels. The mechanical clutches re a source of more or less trouble, and to eliminate hese and also the losses in the continuously running notor and flywheel, several shears have recently been nstalled with d-c. motor drives, arranged to start and top with each cut.

Two of these are in a new plant near Detroit. The arger of the two is an 800-ton slab shear, designed to ut a slab 8 inches thick by 25 inches wide. Another nidwestern steel plant has recently placed in operation ight shears, cutting cold stock up to a maximum of $\frac{1}{4}$ inch thick by 42 inches wide. Some idea of the igh rate of acceleration and retardation may be ob- ained from the fact that the shear makes a complete ycle in less than one second, and during this time the motor starts from rest, attains a speed of over 450 r. p. m., cuts the plate and stops.

A Pittsburgh tube mill has installed two scrap shears for crushing and shearing pipe up to 24 inches. They are of the new type with the shear motors starting and stopping for each cycle.

What is believed to be the first application of synchronous motors to flying shear drive is in connection with a 20-inch hot strip mill in the Detroit District. The shear is of the rotary flying type, and, to insure that the metal shall be cut into equal lengths, it is necessary that the speed of shear be synchronized with the delivery speed of the metal from the mill. To accomplish this, an a-c. generator is provided on each stand, from which the metal may be delivered. The shear is driven by a synchronous motor, the power for which may be obtained from any of the a-c. generators.

Three ore unloaders recently placed in operation at one of the Lake Erie Docks are interesting on account of their large size. The combined capacity of the three unloaders is 3,600 tons per hour, and the actual time for unloading a 10,000-ton boat is four or five hours. The bucket capacity for each unloader is 17 tons. Each unloader uses eight motors totaling 1,060 hp. The beam hoist motor is a 350-hp., 500-r. p. m., shunt-wound mill motor and the trolley travel motor is a 170-hp. motor, these two motors having variable voltage control. The bucket closing and opening motor is a two-speed wound-rotor mill type motor, and all other motors are a-c. motors. The motor-generator set for the variable-voltage control is mounted inside the beam and serves to help balance the stiff-leg weight.

As electrical improvements in the iron and steel industry are reviewed each year, the opportunities that exist for improvements in steel mill drives and auxiliary equipment become increasingly evident. These improvements will result from a close cooperation between the steel plant engineer, the mill builders, and the engineers of the electrical manufacturer.

Production and Application of Light

ANNUAL REPORT OF THE COMMITTEE ON PRODUCTION AND APPLICATION OF LIGHT*

Production of Light

Statistics on Incandescent Lamp Sales

THE sale of incandescent lamps held up remarkably well during the past year, large lamps showing a decrease of about 1 per cent as compared with 1929. The Central Station revenue derived from the two classes of service in which light is a large factor (domestic and commercial, small power and light) showed an increase of about 7.5 per cent as compared with the previous year, offsetting the reduction from other uses of electricity, and leaving a net increase of about 3 per cent.

The average lumens, watts, and efficiency of the large lamps sold last year all increased as compared with the year before. The average lumens went from 797 to 814; the average watts from 60.7 to 61.2 and the average lumens per watt 13.1 to 13.3.

Of the sixteen standard wattages from 10 to 1,000 inclusive, used in multiple service, three sizes 60, 100, and 200 watts, represent nearly half (46.6 per cent) of the total wattage demand.

The percentage of 110-volt and 115-volt lamps sold decreased slightly, while that of 120-volt gained as compared with the previous year. The percentage distribution for last year for 110-, 115-, and 120-volt lamps was 5.2 per cent, 48.9 per cent, and 41.3 per cent respectively. Lamps for 200-250-volt service decreased from 3.3 per cent to 2.6 per cent of the total quantity sold for multiple service.

The demand for street series lamps is concentrating on the 6.6 ampere rating. This now represents 71.2 per cent of the total; the next largest demand being 14.6 per cent which is for the 15- and 20-ampere compensator type lamps.

New Sources of Ultraviolet Radiation

A new type of lamp (called a glow lamp) has been developed which produces ultraviolet light by virtue of a glow discharge through mercury vapor between two hot cathodes of the oxide coated type. The two heater filaments for the cathodes are connected in series and their resistance produces a sufficient difference in potential to cause a discharge between the two cathodes, once they have become heated. The lamp is rated at 2 amperes and 18 volts. This lamp, designed for operation on alternating current requires a starting potential of some 35 volts, after which 18 volts is sufficient to maintain the discharge. One, two or three lamps may be operated on the ordinary 115-volt lighting circuit in connection with a suitable current-limiting resistance, reactance, or transformer. The glass bulb has been selected for its transmission characteristics so that the lamp will produce practically no radiation below 2,800 Angstrom units. In addition to producing the desirable radiations of ultraviolet light, it also produces blue and green light in the visible spectrum which may possibly be used to advantage in the future to supplement the light of Mazda lamps, to secure a nearer approach to a light subjectively white in color as well as to obtain the healthful ultraviolet radiation.

In last years report a new tungsten-mercury arc lamp was referred to. This lamp consumed about 315 watts. A lamp of the same general characteristics, but of about forty per cent of this wattage has recently been announced. The bulb is smaller, and is fitted with a metal cap which raises the operating temperature and pressure of mercury vapor in the bulb, and increases the efficiency of production of ultraviolet radiation. The ultraviolet output of the new lamp is approximately one-half of that of the older one. The transformer to be used with the new lamp weighs about 7½ pounds and is small enough so that it can easily be embodied in the design of fixtures, to permit a wider use of this type of lamp, especially a source for dual lighting service.

Still another type of lamp employing a tungsten filament, operated at a high temperature has been found to produce ultraviolet radiation in the biologically active range in sufficient quantity to be of value at least to poultry and animals where exposure times are not too short. Lamps for such service must, of course, be made with special bulbs which will transmit this radiation, and two sizes, 60 and 500 watts for operation on standard lighting circuits have been made available.

A powerful, long-burning type of carbon arc has been developed for the production of ultraviolet radiation which was described in an illumination item in the December issue of the A. I. E. E. Journal, page 1031.

Gaseous Conductor Sources of Light

An arc, in an atmosphere of krypton and sodium, has been described by Dr. M. Pirani.* This operates in a

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tube about one inch in diameter and 35 inches long which has to be maintained at a temperature of 350 deg. cent. (somewhat above the melting point of lead). A very high efficiency, about 70 per cent of the theoretical maximum, is obtained based on the input to the arc alone. With the supplementary heating required, the over-all efficiency would, of course, be reduced. Previous to this time sodium arcs with efficiencies of from 50 to 70 lumens per watt have been described. The light from such lamps, however, is nearly monochromatic and would, alone, be of limited utility for ordinary lighting service.

Dr. Pirani has also obtained great increases in brilliancy in mercury and in neon discharge tubes.†

The combination of hot cathode neon and mercury vapor lamps to produce light apparently white in color, at a high efficiency, (mentioned in our report for 1928) is again attracting interest, as is also the combination of the mercury arc with incandescent lamps.

Small Gaseous Conductor Lamps

These small negative glow lamps used for night lamps, indicative and current detectors, are now designed to operate on line voltages from 90 to 130, and to consume from 0.01 to 2 watts,. The former is merely an indicator, the latter gives a maximum normal candlepower of 0.2.

Photoflash Lamp

A lamp has been designed to produce a high intensity flash for use in photographic work, consisting essentially of crumpled aluminum foil in an atmosphere of oxygen, which is ignited by a small filament that can be operated on any voltage from 2 to 130. It is made in a bulb of the size and shape of the 100 watt lamp used for general lighting service.

The flash lasts approximately 0.02 second, the radiation is about such as would be obtained from a black body at a temperature of 4,000 deg. K. The flash is equivalent in candlepower to about 250 ordinary 500-watt lamps. It is noiseless and fumeless, the products of combustion being retained within the bulb. The lamp is finding wide use in the photographic field.

40-Watt, Gas-filled Lamp

The 40-watt lamp for ordinary lighting service is being changed from a vacuum to a gas-filled type, and, at the same time put in a slightly smaller bulb. The initial efficiency of the new lamp is slightly higher, and the light output is maintained better throughout life.

50-Watt Lamp

The 50-watt incandescent lamp, for general lighting service, has been removed from the regular schedules of the manufacturers of Mazda lamps. Its demand can apparently be shifted largely to the 60-watt size which is gaining steadily in popularity. The three sizes, 40, 50, and 60 represented unnecessarily close steps.

New Incandescent Lamps

Three new lamps for 110-, 115-, and 120-volt lighting service have recently appeared on the market. These are, a 5-watt lamp in a bulb ¾ inch in diameter, a 100-watt in a tubular bulb 34 inches long, and a 150-watt in a tubular bulb about 12 inches long.

Application of Light

Ultraviolet

The utility of ultraviolet radiation for purposes, other than merely the prevention of rickets, has been attracting wide attention and has been the subject of much experimental work. Its most promising physiological benefits seem to lie in the direction of prevention of colds and relief of anaemia. In the industrial field powerful carbon arcs are used for making accelerated tests (which must however be carefully evaluated) and for the treatment of food, tobacco, and other products. Small incandescent sources can be used in poultry houses with good effect.

The use of screens with arc sources to absorb the ultraviolet radiation shorter than that which it is desired to use, has grown during the past year, particularly in outfits intended for use in the home. A time limit switch is also incorporated with some outfits to reduce the probability of over-exposure. The development of very powerful arc sources with long-burning carbons, has extended the possible use of ultraviolet radiation in both industrial service, and in treating large groups in hospitals and sanatoriums.

Trends in Lighting Practise—1930

The interest of architects and decorators in the use of artificial light as a component part of their decorative scheme, is becoming more and more widespread. At first the new ideas were accepted in only the larger cities, now in most of the smaller cities and larger towns excellent examples of the new practise can be found.

Instead of trying to imitate flame sources, candles and oil lamps in fixtures intended for rooms of classical treatment, the skillful designer produces a luminaire which serves the modern light sources in an effective manner and then incorporates in the detail of decoration elements which are inherent to the decorative period under consideration.

The more commercial or stock fixtures which have appeared on the market during the last few months exhibit a tendency to new forms, characterized in general by simplicity of line and pleasing proportions.

If satisfactory illumination is to be obtained from side wall outlets, these must be fitted with some sort of device quite different from the ordinary candlestick bracket. Manufacturers are beginning to realize the possibility of so-called semi-indirect, side wall pockets or urns and a number of interesting varieties have been placed on the market during the period under consideration.

Only a few years ago it was the practise to finish the building and then choose the lighting fixtures. As a

**Zeitschrift fur Technesche Physik*—Nov. 1930.
†*E. T. Z.*,—June 1930.

result they often tended to appear as an incongruous after-thought, and not a component part of the structure. We are now seeing many instances of what has been termed "built-in" lighting, but these arrangements cannot be carried out unless suitable provision is made in the initial plans for the placement of lighting equipment.

There is a growing appreciation of the value of light to look at (as well as to see by) and in the more modern buildings we see interesting installations of luminous panels, niches, and touches of color which give no useful illumination but are pleasing to the eye.

Naval architects and ship owners realize that their vessels must be made more interesting from a decorative standpoint if they are to attract patronage under conditions of severe competition, and decorative lighting is receiving more attention than ever before in marine service.

There seems to be a trend in commercial lighting practise toward the greater use of indirect lighting equipment, both semi-indirect and totally indirect. Such forms of lighting which are desirable for general use in commercial interiors have been rather slow in being adopted probably because they require better maintenance than the enclosing globes.

Technical progress has been made in practically every field of lighting. In some of the newer ones, such as lighting for outdoor sports and for aviation, there has, in addition, been a very rapid growth. There have been no revolutionary changes, however, in equipment and methods generally employed.

Windowless Buildings

Perhaps the most outstanding development in connection with the use of daylight or artificial light for buildings that has taken place to date was started during the past year. The new factory of the Simonds Saw & Steel Company, Fitchburg, Mass., which is now nearing completion is built entirely without window openings. This pioneering project is receiving much publicity and the results will unquestionably be watched with interest and have a distinct bearing on the future building construction. In this building lighting units consisting of a combination of mercury vapor tubes and tungsten filament lamps will be used to secure a subjectively white color of light. Some of the tubes will be of ultraviolet transmitting glass to provide the desired amount of such radiation. Another notable example of this nature is the Parker Bridget Department Store in Washington, D. C. This store depends entirely on artificial illumination for its operation. It is felt that by eliminating windows lighting conditions are constant at all times. It is much easier to accurately control temperature and ventilation. Then, too, from a merchandising standpoint the larger percentage of wall area is available for display space.

With the record for continuity of service which has been attained by the central stations, and the development of effective means of lighting, ventilation and air conditioning, windows are no longer essential. There are so many advantages to be gained by their elimination in certain classes of use, that it appears as though this subject will receive increasing attention in the future.

Proper Operating Voltage

The N. E. L. A. Lamp Committee gives in its report this year, the results of further surveys of socket voltages, which show some improvement in the average value as compared with the sample cities studied the year before. The spread in voltage, however, shows no improvement. The results given in these surveys apply particularly to residential service. In large office buildings and industrial plants the average socket voltage is probably relatively lower than in residential service because of the greater voltage drop in interior wiring.

The N. E. L. A. Lamp Committee Report for 1928 contained a summary of data on operating voltages as reported in use for some 18,000 communities. This summary showed that 5.4 per cent of the population considered was in communities served at more than one standard voltage. Five years earlier the percentage had been 13.2. This trend toward the use of one standard operating voltage in each community aided in putting lamps of correct voltage in service, because, it is obviously difficult, if not impossible, to avoid mixing voltages in service where two or more standards are in use. The maintenance of but one standard service voltage throughout a community makes it much easier to be sure that lamps of only the correct voltage are used, and this is important from the standpoint of lighting service in general.

Minimum Wiring Specifications

In addition to the minimum specifications for the adequate wiring of lighting circuits in commercial and public structures, mentioned in last years report, specifications covering industrial and residential service will soon be made available as a result of further work by N. E. L. A. Committees. All of these specifications are in such simple form that they can be used with the greatest ease. They provide minimum standards to which all new buildings should conform in the interests of good lighting service. We again recommend that every electrical engineer who is brought into contact with the design or operation of lighting installations should be familiar with these specifications.

Stroboscopic Developments

A new type of stroboscope has been developed in which the discharge characteristics of a three-element grid glow tube are utilized in conjunction with a condenser to produce the brilliant flashes of light of exceedingly short duration and high frequency needed in such work. Another method, described in German technical literature produces flashes of the desired character by the combination of motion of three disks carrying different numbers of radial slits. A more complete description

of these devices has been submitted for publication as an Illumination Item.

Group Replacements

The replacement of incandescent lamps in street lighting service in complete groups rather than individually as failures occur, offers a possible means of securing a higher general level of illumination and reducing the number of outages at no increase in operating cost. It is being used, or tried out, in a number of localities. If the burning hours of all the lamps in a large group are identical, and if the cost of replacing lamps individually as they burn out is relatively high, it may be advantageous to replace the entire lot as soon as the burnouts begin to occur with some frequency, which will ordinarily be at the time the lamps have attained about 70 per cent of their average life. If this general replacement is made to coincide with one of the periodic cleanings of the lighting equipment the replacement cost per lamp is relatively small. This same practise might well be applied in other classes of service, where the cost of making individual replacements is relatively high, and where all the lamps in a large group burn the same length of time.

Fixed Focus Automobile Headlights

It has long been recognized that one of the greatest factors contributing toward glare from automobile headlights has been the fact that the lamp filaments were not properly focused in the reflectors. Although the system of approval of headlight equipment by the motor vehicle authorities of the various states after laboratory test has become quite general and all cars are equipped with head lamps capable of producing adequate road light with minimum glare, it has been impossible to keep these equipments in proper adjustment in the hands of the public. The motorists may learn to aim the headlight beams properly, but the more intricate operation of focusing the filament in the reflector has proved a stumbling block.

Because improvements in lamp manufacture now permit more accurate location of the filaments with respect to the lamp base, and because headlight reflector and lens combinations have been designed that are less sensitive to focal adjustment, it has become possible for the motor vehicle authorities to approve the use of so-called "fixed focus" headlamps from which the focusing mechanisms are entirely eliminated. The sockets in these headlamps are rigidly fastened in the reflectors and the filaments in the lamps of any reputable manufacturer in this country are accurately designed to fit them so that an acceptable beam can be secured by simply inserting the lamp in the socket.

Headlamps of this type are already being used by several of the motor car manufacturers and improvements in the general headlight situation are to be expected as their use becomes more widespread and cars with the old types of equipment are gradually replaced on the highways.

General

Present Status of Candlepower Standards

While the needs of practical photometry have been met reasonably well for many years by the expedient of establishing units of candlepower maintained by means of electric incandescent lamps, this procedure does not give a permanent solution for the problem of photometric standards. There remain unsettled three major difficulties: 1. Several countries, particularly Germany and Austria, still use the Hefner unit, which is 0.9 of the unit recognized by the International Commission on Illumination; 2. no reproducible primary standard has been accepted as representing the international unit which was established for carbon-filament lamps; 3. no specific method has been agreed upon for passing from the carbon-filament lamps to those giving light of other colors.

These difficulties have resulted in discrepancies between measurements made in different countries. The differences are large enough to be very serious in such precise measurements as are made in rating and testing incandescent lamps. Consequently efforts have been made for several years to find a basis for a comprehensive international agreement on this subject. These efforts have been furthered by discussion at several sessions of the International Commission on Illumination. In order to give a more definite legal status to the negotiations the International Committee on Weights and Measures decided in 1929 to take up the problem of photometric units and standards, collaborating with the Commission on Illumination. Both of these organizations meet in 1931, and it is hoped that some definite progress can be made toward the solution of the problem.

As a basis for action, an international Advisory Committee on Electricity, meeting in June, 1930, has prepared recommendations which may be summarized briefly as follows:

1. As a *primary standard of light* a black-body radiator is definitely recommended; other laboratories are asked to consider the specific form of standard which has been developed by the Bureau of Standards, and to make determinations on that form or on others which will be comparable with it.

2. As a *unit* for general use the present international candle is to be retained.

3. Present discrepancies between basic units at carbon-filament color as maintained in the different national laboratories are to be reconciled by comparisons now in progress, and thereafter periodic comparisons and necessary adjustments are to be made under the auspices of the International Committee on Weights and Measures.

4. Through comparisons of colored filters now under way between the national laboratories it is hoped that agreement can be reached on a standard method for measuring lights of various colors. This method can then be used in setting up practical standards for lamps of various types, all based upon the primary standard and all consistent with each other.

Architects and Lighting

During the past year the Illuminating Engineering Society has given great attention to securing better

cooperation between the architects and illuminating engineers. As one approach to this problem, three very well attended schools on architectural problems have been held, one at Columbia University, one at Chicago, and one at the Massachusetts Institute of Technology. Such schools for illuminating engineers serve to acquaint them with architects' viewpoints and nomenclature, thus helping to bridge the gap between the two professions. On the part of practising architects greater attention than ever before has been given to coordinating lighting with building design.

Important steps have been taken in fostering better lighting in the homes and schools of the United States. In this manner the best principles of lighting have been made available to school boards and home owners. This work is spreading rapidly.

A code of principles of Street Lighting has been prepared by the Street Lighting Committee of the Illuminating Engineering Society, which is likely to take a very important part in guiding the practise in this field. For the first time experts and engineers representing diverse interests and viewpoints have been able to agree upon a statement of some of the fundamental factors involved.

The Lamp Committee of the National Electric Light Association presents each year to that association a report in which the statistics relating to incandescent lamp production are analyzed in detail, and in which important developments in the production and application of light are reviewed. Those who wish more detailed statistics, as well as those who are concerned with the commercial and engineering problems of lighting, will find valuable the reports of various committees of the National Electric Light Association and the Illuminating Engineering Society.

The Committee wishes to record its appreciation for the assistance rendered in the preparation of this report by Dr. E. C. Crittenden (who contributed the section on the Present Status of Candlepower Standards), Mr. A. L. Powell, and Mr. A. B. Oday.

Applications to Mining Work

ANNUAL REPORT OF COMMITTEE ON APPLICATIONS TO MINING WORK*

THERE has been a minimum of new installations made this year owing to the general depression.

Hoists. Probably fewer hoists have been installed than in many past years. It is interesting to note that two manufacturing companies alone report that combined they have sold to date nearly 800 induction motor hoists from 200 to 1,800 hp. in size, and over 100 variable control d-c. hoists from 200 to 5,000 hp., the latter two motors in series.

Cleaning Plants. There is a continued trend toward larger and more complete preparation plants especially at mines using mechanical loading instead of hand loading. One plant, Hazle Brook Coal Co., has installed two 200-hp. Westinghouse synchronous motor drives.

Shovels. Electrification of 4- to 10-yard shovels has continued in the metal mines.

Mining Machines. The manufacturers of this specialized electrically driven equipment have been very active in producing new types of mobile high-powered machines. These machines now undercut from 600 to 1,200 tons per day in contrast with older types which did well to undercut 200 tons per day. See Fig. 1.

Loading Machines. Rapid increase of the amount of coal mechanically loaded indicates that these labor saving devices are permanently established in the industry. Various makes have sustained records of 350 to 500 tons loaded per 8 hours. Probably there are 500 such machines now in operation.

Welding. In addition to miscellaneous repair work by electric arc welding several companies have installed full automatic welding heads to be used for filling up the worn tread of locomotive tires and wheels. This has been quite successful and undoubtedly will be very generally used.

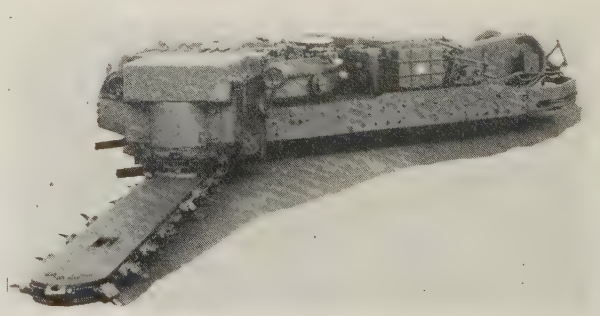

FIG. 1—JEFFREY 29L TRACK-MOUNTED CUTTER

Safety Work. The Bureau of Mines has continued to test and approve many new devices for mining work.

NOTE: Many references to miscellaneous improvements and applications are given in the *Coal Age*, Vol. 36, No. 2, Feb. 1931, p. 76.

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Applications to Marine Work

ANNUAL REPORT OF COMMITTEE ON MARINE WORK*

THE major items of activity of the committee for the current term have been:

a. Reprinting Standards No. 45—Recommended Practise for Electrical Installations on Shipboard.

b. Promoting licensing of the electrical operating personnel on shipboard.

c. Keeping in touch with electric propulsion of ships and the electrification of auxiliaries on shipboard.

Standards No. 45

During the last term of this committee these standards were completely revised to incorporate developments and expansion in the marine practise since the previous issue of June 1927. They were carefully edited and reprinted in October 1930 and are being rapidly sold to all departments of the marine industry interested in electrical work. These standards are recognized and accepted by the various marine classification and insurance societies, naval architects, marine engineers, shipbuilders, and ship owners and are being incorporated in many of the specifications regulating the construction and repair of ships. The increasing use of them testifies to the need of such rules in order to standardize the electrical installations on shipboard and to stimulate the use and proper care of electrical machinery in the marine field.

Fig. 1—View in Lower Engine Room, *S. S. Morro Castle*

Propulsion motor in background

They are referred to in the various rules of classification societies not as a requirement but as representing good practise. This regard for these rules is justly merited due to the many years of hard work by experienced representatives of the diversified interests composing the marine field.

The fire alarm rules in the present Steamboat Inspection Service are consistent with the Standards No. 45 and were referred to this committee during their preparation.

Operating Personnel

Our efforts were continued with the Steamboat Inspection Service to obtain classification and rating for electrical operating engineers on shipboard.

Fig. 2—View in Upper Engine Room, *S. S. Morro Castle*

Propulsion control at left and generators at right

A review of the work of the subcommittee in charge of this item carries one back to the year 1922 when overtures were made to the Steamboat Inspection Service to require the operating personnel on vessels with electric plants to qualify and obtain electrical licenses.

The committee's efforts to date have been rewarded by a slight raising in the standard of the electrical

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questions in the examination for license for steam and combustion engineers.

The Board of Supervising Inspectors has been very courteous and granted a number of hearings. The necessity for the requested action, is recognized by a few of the supervising inspectors and it is hoped that there will soon be a sufficient number to put the movement into effect.

The cause for this movement was the improper maintenance of electrical equipment on shipboard and is today perhaps more prominent than when the movement was started owing to the increase in the use of electrical apparatus and auxiliaries, with the exception of vessels equipped with electric propulsion and all of these are not immune.

On electrically propelled vessels the standard of the electrical force is somewhat higher than on other vessels. Consequently, the electrical apparatus and auxiliaries receive the benefit of more expert attention.

The committee has been in touch with the President of the American Steamship Owners Association soliciting its good offices. Our committee was cordially received and has been requested to submit its proposal relative to the absence of knowledge and training on the part of the operating personnel. This proposal is almost complete and it is hoped it will be submitted at an early date.

The subcommittee is keeping in close touch with this situation and is optimistic in feeling that favorable action will be taken by the Steamboat Inspection Service before long and their regulations modified accordingly.

Electric Propulsion and Electric Auxiliaries

The year 1930 takes its place in marine history of the United States with a record of activity, progress, and accomplishment in shipbuilding and marine engineering, which has not been approached since the busy days of the World War. This is, of course, due largely to the stimulation resulting from the Jones-White Merchant Marine act of 1928, which has made available to American ship operators, large mail contracts and loans at low interest rates for construction of new vessels. Thus, our merchant marine is to receive a much needed strengthening by the addition of a fleet of fine ships now under construction or in process of design.

In the design of these last words in naval architecture, electricity has taken an outstanding place. Some will be propelled by means of electricity. All will have electrically driven auxiliaries which are so necessary to the operation of the ship. Electrical appliances will add to the comfort and convenience of the passengers.

In order to illustrate the progress of electric propulsion especially during the past year the following data covering vessels completed or contracted for to January 1, 1931, are listed below.

	Hp.	No. vessels
Total turbine electric in U. S. A.	867,600	62
Total turbine electric outside U. S. A.	127,900	9
Total	995,500	71
Commissioned or under construction during 1930 in U. S. A.	196,900	20
Total diesel electric in U. S. A.	88,280	121
Total diesel electric outside U. S. A.	16,700	8
Total	104,980	129
Commissioned or under construction during 1930 in U. S. A.	15,195	25

It may be interesting to know the individual vessels and their horsepowers involved in the above figures.

Name	Horsepower
Turbine Electric Drive—Ships Commissioned During 1930 in U. S. A.	
Santa Clara	12,600
Morro Castle	16,000
Oriente	16,000
City of Flint (Great Lakes Car Ferry)	7,200
Corsair	6,000
4—Coast Guard Cutters	12,880
2—River towboats	4,000
Total	74,680
Turbine Electric Drive Equipments—Under Construction During 1930	
President Hoover	26,500
President Coolidge	26,500
United Fruit Co.—6 ships 11,000 hp. each	66,000
One Coast Guard Cutter	3,220
Total	122,220
Diesel Electric Drive—Installed During 1930	
Frying Pan—Lightship	350
Fenwick Island—Lightship	350
Nantucket—Lightship	350
Tidewater—Tanker	1,000
Ward Island—Ferry	400
Tenkenas—Ferry	400
Veedol No. 2—Tanker	1,000
L. T. C. No. 1—Tanker	500
L. T. C. No. 2—Tanker	500
L. T. C. No. 3—Tanker	500
Liston—Survey Boat	350
Scott—Towboat	150
Ft. Armstrong—Towboat	150
Cleveland—Tug	800
Rochester—Tug	800
Scranton—Tug	800
Oleon—Tug	800
Venus—Tug	515
Luna—Tug	515
Prescottont—Tug	800
One tug *Vandyke No. 4.*	425
Total	11,455
Diesel Electric Drive—Under Construction	
One yacht	660
One tanker	200
One fireboat	2,130
One ferryboat	750
Total	3,740

Prior to the commissioning of the *S. S. California* in 1928 the total turbine-electric horsepower installed on merchant ships was but 38,800. Out of a total of 356,200 horsepower completed and in course of construction as of the end of 1930, 317,400 horsepower, or

89 per cent, was undertaken during the past three years.

Slightly apart from the marine field, but with equal interest to it, was the installation of a central station in the *Jacona*, which is to be used as a mobile and subsidiary power plant along the shores of the New England Coast. Two turbine generators were installed, each rated 10,000 kilowatts for delivering power ashore at 6,600 volts or 11,400 volts three-phase 60 cycles.

FIG. 3—AUXILIARY D-C. SWITCHBOARD, *S. S. Morro Castle*

During 1930, a 96-in. (wheel diameter) gyroscopic stabilizer complete with electrical equipment, was constructed. This unit will be installed in a large yacht. A second unit with 11-ft. diameter wheel, complete with electrical driving motors, control and turbine generator set for power supply, is nearing completion for installation on one of the largest yachts ever built. The casing of this stabilizer will be of welded construction.

During the year 1930 great strides were made in shipboard installations of modern watertight door control systems. This system provides that in the event of collision electric operation of the watertight bulkhead doors is instantly available. The system provides remote control of the watertight doors from the wheel house as well as at the door itself.

It is the intention of this committee to keep Standards No. 45 up to date and assist in any practicable way the various classification societies and other bodies or interests in the marine field in the application of electricity to marine use.

We further are ready to cooperate with the American Marine Standards Committee in establishing electrical marine standards such as watertight receptacles, etc.

Power Generation

ANNUAL REPORT OF COMMITTEE ON POWER GENERATION*

TWO meetings of the entire committee were held during the year, one at the Philadelphia District Meeting on October 14, 1930, and the second at the Winter Convention in New York on January 28, 1931. In addition to the regular survey of immediate developments and problems in the scope of the committee, a continuing organization or method was adopted through which news items on the subject of power generation will be reported for publication in ELECTRICAL ENGINEERING. Each member of the committee was asked to appoint some one of his business associates as a permanent news correspondent to represent his particular affiliation irrespective of membership in the future on the Power Generation Committee.

The subject of interconnection continued to occupy the major attention of the committee, and especially of the Joint Interconnection Subcommittee on which Messrs. F. C. Hanker, F. H. Hollister, and A. E. Silver represented the Power Generation Committee. The formation of this subcommittee composed of members from the Power Generation, Power Transmission and Distribution and Protective Devices Committees, was predicted in last year's report, and the subcommittee has functioned throughout the year under Mr. Hanker's chairmanship not only to the fullest extent, but has also promoted a close working arrangement among the three main committees in dealing with a subject that has many common elements.

The Joint Interconnection Subcommittee has directed the preparation of a second report on "Grounding," which was presented at the Pittsburgh meeting in March 1931 under the title *Present Day Practise in Grounding of Transmission Systems*, and while of technical import to this committee, is also of interest because the original report on *Grounding* was prepared in 1923 by Mr. E. C. Stone now of the Power Generation Committee.

The Interconnection subcommittee has also sponsored a session in this summer's convention, consisting of four papers that treat the subject of interconnection primarily from the viewpoint of geographical, as contrasted to urban territory, interconnection. The introductory paper, prepared by Mr. Alex. E. Bauhan, is a comprehensive summary of the various services rendered by interconnection, and an exposition of the methods of evaluating the economies to be secured. Two papers that illustrate the plans and operating procedures adopted in different regions, are as follows:

Interconnection in New England, by E. W. Dillard and W. R. Bell; *The Pennsylvania-Ohio-West Virginia Interconnection*, by Howard S. Fitch.

The fourth paper, by G. M. Keenan, is on *Load and Frequency Control on Interconnected Systems* and summarizes the methods in use and the experience on the subject that has accumulated in the past two to three years on practically all the major system interconnections in this country.

The committee reviewed during the year and recommended as of great interest on the subject of interconnection other papers as follows:

Governor Performance During System Disturbances, by R. C. Buell, R. J. Caughey, E. M. Hunter, and V. M. Marquis.

Reestablishing Excitation of a Loaded Alternator in Parallel with Others, by D. D. Higgins and E. Wild.

Other papers describing the design of modern power plants that have been reviewed by the committee include the following:

The Ohio Falls Hydroelectric Station at Louisville, Kentucky, by R. M. Stanley and E. D. Wood.

Modern Steam Stations of Duke Power Company, by Marshall E. Lake.

Steam Power Development of the Pacific Gas and Electric Company, by Richard C. Powell.

Two papers with an introductory summary have been initiated and are now in preparation on the subject of steam and electric drives. These papers are being written in collaboration for the purpose of uniform presentation, and are scheduled for one of the fall meetings this year.

Another activity initiated that will result in a symposium during the 1932 Winter Convention, is suggested by the lack of information reported to the committee on the subject of system operation from the viewpoint of economy and reliability in carrying load schedules. There is considerable literature relating to load division among boilers and generating units

*COMMITTEE ON POWER GENERATION:

F. A. Allner, Chairman,
F. A. Annett, J. R. Baker, T. J. Bostwick, J. B. Crane, H. W. Eales, N. E. Funk, D. L. Galusha, R. B. Gerhardt, W. S. Gorsuch, F. C. Hanker, C. F. Hirshfeld, F. H. Hollister, A. H. Hull, G. A. Jessop, H. W. Leitch, E. B. Meyer, E. L. Moreland, I. E. Moultrop, G. E. Quinan, F. A. Scheffler, A. E. Silver, W. F. Sims, A. R. Smith, E. C. Stone, R. W. Stovel.

in single stations, but new problems in load allocation have resulted from the extensive interconnection of systems previously operating as separate units. It is planned to secure a series of papers describing the practise of at least three of the larger operating systems on which steam generation is exclusively employed, and to reserve the subject of combined steam and hydroelectric sources for later discussion.

The Progress Report which follows, covers the developments of the past two years. Together with a bibliography of the more salient literature on power generation.

Recent Developments and Present Status of Power Generation

Volume and Distribution of Generation

The combination of a two-year drought and the business depression had a marked effect upon the distribution of the total electric generation in the United States between fuel burning and hydroelectric plants. From 1921 and 1928 the average yearly increase in total generation was quite uniform at 11.5 per cent, in fuel generation at 10.9 per cent, and in hydroelectric generation at 12.7 per cent. Applying these average rates to the figures for 1928 there is a calculated deficit at the end of 1930 of 12.1 per cent in total generation, 4.0 per cent in fuel generation, and 32.5 per cent in hydroelectric generation. These figures show that the loss in hydroelectric generation caused by the drought allowed fuel generation almost to hold its normal increase notwithstanding a decrease of 1.5 per cent in total generation in 1930. The total generation in 1930 was 96 billions, of which 34.6 per cent was generated in hydroelectric plants in contrast to 40.4 per cent in 1928.

Generating Plant Building Programs

The added steam generating capacity in the United States in 1929 was secured by about 57 per cent in new plant construction and 43 per cent in additions to existing plants. The total added capacity was nearly 2,250,000 kw. It is interesting to note that in 1930, in spite of the fact that the total electric production for the year was about 1.5 per cent below that of 1929, there was nearly as much steam generating plant capacity added as in 1929, a total of slightly over 2,000,000 kw. This was divided 47 per cent in new plants and 53 per cent in additions to existing plants. Apparently the depression of the past year is to be reflected in the amount of capacity contemplated for 1931 additions, which is about 1,250,000 kw. These additions are mostly in existing plants where the added capacity is 75 per cent of the total, a condition approaching that of 1928, when practically all of the new steam capacity was in additions to existing plants.

Compared to 1928, the number of new hydroelectric plants and the capacity installed in 1929, was strikingly small; the new installations in 1930 were over three times greater than in 1929, but they still were appreciably less than in 1928. The plants now under construction that will be completed in 1931 will total about 50 per cent of the additions to capacity in 1928, while present indications are that the new capacity developed in 1932 will be only a fraction of the 1931 installations. Contrasted to the schedule of immediate construction are the probabilities within the next few years of the super-capacity plants that are being considered on the Columbia, Colorado, and St. Lawrence rivers.

Major Influences in Current Design of Steam-Electric Plants

The fundamental factors influencing the design of modern steam-electric generating plants are about the same as those which dictated design in the past. They are only modified by new and better apparatus now available, such as improved and alloy steels which make possible the use of higher pressures and temperatures, improved fuel burning equipment and furnaces which permit of much higher boiler ratings and greater efficiences, together with numerous other improvements in auxiliary apparatus.

For a number of years the tendency of steam plant investment costs was upward and these increased costs were justified by the considerable improvement in economy. The point has now been reached where improved efficiencies are becoming increasingly difficult to secure, and any increase in capital cost is difficult to justify. It would seem, therefore, that the effort to lower production costs must lie in reductions in capital investment through simplified design, raising the output of the equipment, and increasing the capacity for a given unit of space.

Probably the most attractive feature in a program of simplification is the possibility of reducing the number of boiler units for a given turbo generator output. Reports published within the last year indicate that the modern boiler has a reliability factor practically equal to that of the turbo generator. It would, therefore, seem that spare boiler capacity should be considerably reduced over past practise up to the point where boiler and turbine capacity would be equal. In other words, the boiler and turbine might be considered as one complete unit. This would be particularly practical where there are several units in the same station, in which case a certain degree of flexibility could be secured where a boiler and turbine forming separate units might be out of service, in the one case for boiler inspection or repairs and in the other case for turbine inspection or repairs.

The greater cleanliness in the operation of fuel preparation and feeding apparatus will now permit the installation of turbines, boilers, and fuel equipment in single buildings without the use of the dividing walls which have up to this time been considered necessary. There has been a number of instances where plants have been constructed without these walls and are

giving very satisfactory operating results. The omission of dividing walls not only saves the cost of the wall but reduces the amount of building steel and permits of a more compact arrangement of apparatus, thus bringing about a natural reduction in the cubic contents of the building. In certain cases a reduction in operating labor has also been secured.

Outdoor installations of boilers, turbines, and electrical equipment are advocated by some engineers and many attractive studies have been brought forth. To date, however, no large outdoor installations have been projected. While such installations are not in entire favor with operating engineers the reduced investment has made the designs of interest.

In practically all of the older designs there was a great deal of duplication in the piping layouts. Numerous cross connections, loops and sectionalizing valves were used, partly with the idea of protecting against failure of any part of the piping system and partly due to the desire to protect against failure of apparatus used in the feed-water heating cycle. Experience with operation of piping, valves, and equipment has shown that their factor of reliability is, in general, as great as that of the turbines and boilers. The opinion has

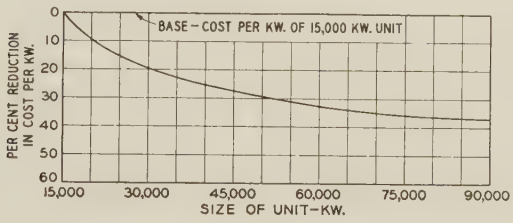

Fig. 1—Per Cent Reduction in Unit Cost of Single Shaft Turbo-Generator Units Designed for 450 Lb. 775 Deg. Fahr. Steam

frequently been expressed that provisions made for cross-connecting and sectionalizing have never been used even though they have been in the plant for a considerable number of years. Simplification of piping design and reduction in number of valves, joints, etc., would reduce both the capital expenditure and the operating cost.

Considerable thought has been given to reducing the number of duplications of auxiliary equipment, such as condensate, air and circulating pumps for turbo generator units. In designs where several spare boilers were provided it was the practise to install single auxiliaries such as stoker drives, forced and induced draft fans, whereas on the turbo generator units it was customary to duplicate the auxiliary equipment. With the present consideration being given to reduction and possible elimination of spare boilers, the question of duplication of auxiliaries should be carefully considered. The usual argument that it is good insurance to protect the large unit by the installation of duplicate and comparatively cheap auxiliaries, carries some weight. Against this, however, must be balanced the lower capital and operating costs by minimizing the number of pieces of apparatus and simplifying the piping design.

The use of larger units, both boilers and turbines, has resulted in a lower unit cost of equipment and in a marked reduction in the cost of the building per kilowatt of capacity. There is a number of installations either already made or pending, where the capacity of the new turbo-generator unit is from two to three times that of the unit for which the building was originally planned. It is evident, therefore, that the

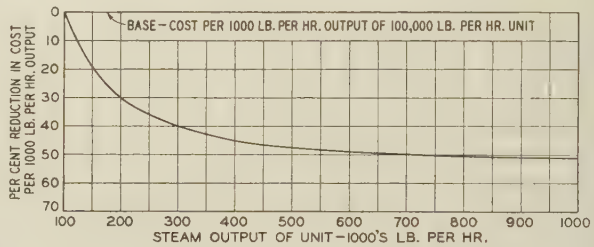

Fig. 2—Per Cent Reduction in Cost of Boiler Units Designed for 450 Lb. 775 Deg. Fahr. Steam

Prices used in plotting the curve include cost of boiler, superheater, soot blowers, air heater economizer, and pulverized fuel equipment

cost of this portion of the building per kilowatt would be reduced to one-half or one-third of the original cost. A few years ago the cost of buildings per kilowatt of capacity was roughly $30. It is, therefore, evident that the possible savings in building alone due to use of larger equipment results in a material reduction in cost per kilowatt. This would have a particular application where equipment is to be installed in a vacant space in an existing building or where it is desired to increase the capacity by replacing equipment in an old plant which is strategically located in the distribution system.

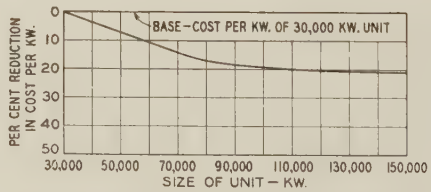

Fig. 3—Per Cent Reduction in Cost of Single Shaft Turbo-Generator Units Designed for 1,000 Lb. 775 Deg. Fahr. Steam Reheated to 775 Deg. Fahr.

The reduction in floor area has assumed importance not only from the standpoint of building and land value but from the resulting reduction in cost of much of the piping and auxiliary equipment. In order to reduce the floor area some of the modern designs resorted to the vertical compounding of units as typified by the Jersey Central Power and Light Company and the Pacific Gas and Electric Company where a high pressure turbine and generator are mounted on top of a low-pressure generator. By such means and by the

increase in the maximum size of turbines from 50,000 kw. in 1920 to 200,000 kw. at present, the floor area has been reduced from an average of 42 sq. ft. per installed kilowatt to less than half that area.

Typical of this trend are the Ford Company in which a 110,000-kw. unit is to be installed where one 12,500-kw. unit is being removed; the Hell Gate Station of The United Electric Light and Power Company where two 160,000-kw. units have been installed in the space designed for two 35,000-kw. units and the Hudson Avenue Station of The Brooklyn Edison Company, Inc., where two 160,000-kw. units have been purchased for the space designed for two 50,000-kw. units.

Along with the increase in size of turbines the weight per kilowatt including the generator has been reduced in the past ten years from about 28 lb. to 15 lb.

The curves in Figs. 1, 2, and 3 will give an indication of the trend toward lower costs with increased size of turbo generators and boilers per unit of capacity. Figs. 1 and 2 represent respectively cost trends for turbo generator and boiler units designed for 450 lb. pressure and 775 deg. fahr. total temperature. Fig. 3 is representative of a compound single-shaft turbo generator where the initial steam condition would be 1,200 kw. and 775 deg. fahr. total temperature, with steam bled at 400 lb. and reheated to the initial temperature.

Along a line totally different from the selection and arrangement of equipment, and also for the purpose of reducing the cost of power generation, has been the cooperative interconnections adopted in the last few years between steam-electric stations and industrial plants. The latter in some cases require large quantities of steam under conditions that may or may not be suitable for the supply of power necessities; in other cases the industrial plants may have the disposal of byproduct fuel either solid or gaseous. It has been found advantageous to both parties in a variety of industries to arrange both electric and steam interconnections whereby power and steam are generated in the most economical fashion, and the fullest benefit derived from diversity in power, steam, and byproduct conditions. In many instances the electric plant supplies both steam and electricity, requiring certain modifications in the standard feed water system. Recent literature has described such arrangements at Deepwater, New Jersey, Rochester, New York, Toledo, Ohio, Baton Rouge, Louisiana, Mobile, Alabama, and Cedar Rapids, Iowa.

Factors at Present Determining Maximum Size of Boilers and Turbines

While large unit size turbo generators reduce the cost per installed kilowatt they sometimes represent a greater capital charge for reserve capacity. A check of available published information regarding peak loads and installed capacity in fourteen large central station systems indicates the following reserve capacity in per cent of the total installed:

Four systems were between 30 and 36 per cent.
Seven systems were between 20 and 30 per cent.
One system was about 17 per cent.
Two were less than 10 per cent.

The same published information indicates that the two systems having the smallest reserve capacity have a substantial percentage of purchased power, so that it is very probable that actual reserve capacity would be materially increased by available spare capacity through interconnection. In one of these systems, where the per cent of reserve capacity is the greatest, it is known that the generator capacity reported on was not all available at the time the tabulation was made, since the boiler capacity in one of the principal plants limited its capacity to a point considerably below the generator name plate ratings. The selection of the very large units in some of the recent developments may have been due to a program of interconnection or expansion which it was estimated would occur within a few years following the installation of the new machine.

Allowance must be made for the loss of the largest unit during operation and also for the possibility of its being out for repairs. If, therefore, units are purchased out of proportion to the size of the system there is likely to result an over-all economic loss. Large units show better performance at comparatively heavy loads. Due to the system reserve requirements it may be necessary to operate at a relatively light load where the economy is poorer. Even the smaller units operating may be affected the same way from the fact of the larger units being on the system. With large units the total amount of auxiliary power requirements for any given system output will also be increased at low system loads. With a large unit carrying heavy load a greater system disturbance would result if the unit should suddenly trip out. Other things being equal the time required for starting a large unit is greater than for one of smaller size.

Transportation difficulties for damaged parts, a longer time necessary for repairs, and larger floor area necessary for dismantling are some of the factors which must be weighed against the lower unit investment and lower labor charges.

Turbine manufacturers have indicated that up to 200,000-kw. capacity in single shaft machines would be feasible. By compounding on multiple shafts the limits, of course, would be considerably higher. One of the limiting features in size would be in connection with the generator and here the use of double windings or raising the voltage will offer a partial solution of the electrical problems.

The limitations to the building of large boilers are more structural than economic. Since at present larger capacity is concentrated in single turbines than in single boilers the problem of boiler reserve is of less importance. Also the experience with pulverized fuel boilers having capacities in the neighborhood of

1,000,000 lb. of steam per hour indicates an availability factor during demand periods approaching 100 per cent.

Large boilers have an exceedingly flat efficiency curve and can be operated at relatively low loads at efficiencies equal to that obtainable from boilers of smaller size. The parts involved in boiler construction are small and do not involve any transportation problems.

Rehabilitation of Existing Steam Plants

Many studies are still being made by steam station designers to increase station capacity by means of improved thermal cycles using higher temperatures and pressures, but not much actual revamping has taken place in the past year or so because of the falling off in power station demand and construction. Then again, while many studies of rehabilitation have been made, all recent improvements in steam station design have been quite broad in their application involving considerable major equipment. Generally speaking, where there has been a demand for increased capacity it has been for such large increments that invariably more consideration is given to the building of new stations with units of large capacity than to some modification of existing generating facilities.

Some steps looking to improved steaming have been taken, such as the installation of water-cooled walls frequently combined with pulverized fuel firing with resultant greater output from the same boiler; also, the installation of air-heaters resulting in a reduction of stack losses. Recent studies made on binary cycles indicate that improvements in efficiency can be made in old plants employing old boilers.

The important recent developments of interest to steam station designers both in the United States and abroad which will, no doubt, in the future have a great influence on rehabilitation, have been:

a. The installation of a 10,000-kw. mercury turbine in the South Meadow Station, Hartford, Connecticut.

b. The installation of high-pressure steam (750 lb.-2,800 lb.) units at Langerbrugge Power Station in Belgium.

c. The construction of new peak load plants in Germany of low pressures.

d. The construction of heat storage plants in Germany.

Rather than follow these lines of securing an increase in capacity and improvements of economy by changes in old stations, the trend in American practise is, with a few exceptions, more along the lines of building new efficient high-pressure steam plants and utilizing interconnections to a greater degree for permitting the operation of the new stations at high capacity factors on base load, and retaining the older less efficient stations for peak loads. With ample interconnections, addition of new capacity at old load centers is not often thought to be as economically advantageous, everything considered, as establishing new generating points where ample land, rail, and water facilities are available.

Reduction in Operating Costs of Steam-Electric Plants

The production of electricity from steam central stations has developed so remarkably in the last decade that it seems fitting in this report to review the progress that has been made during this time.

The average unit production cost has decreased about 50 per cent. The heat consumption per kilowatt hour has been reduced from about 30,000 B. t. u. in 1920 with a best record of 18,000, to an average of 18,500 B. t. u. in 1930 with the best record approximating 12,500 B. t. u. This is for stations using steam only. The mercury steam cycle installation at the South Meadow Station of the Hartford Electric Light and Power Company reports an average heat consumption of around 10,500 B. t. u. per kw-hr.

The progressive increase in the size of turbo generator and boiler units together with the improvements that have resulted in the reduction of supervisory requirements have brought about a constant decrease in labor costs. Great improvement has been made in control equipment with the consequent extension of the scope of supervision of individual operators.

Boiler maintenance costs have been reduced by the use of cooled furnace walls and from the studies by engineers of the effect of operating conditions on maintenance, with a consequent increase in availability of equipment.

Allocation of the load to various stations of a system on a basis which gives a minimum combined cost for each momentary change in load demand and at the same time taking into consideration the effect of loading on the maintenance of equipment, losses incidental to starting and labor costs, has brought about a great reduction in operating costs.

For example, for any particular load demand on the system there is one combination of units and loads at the various stations which will give the lowest combined cost for the system. The determination of this equipment set-up is made by grouping various combinations of units at the different stations through the use of cost input-load output and incremental cost characteristics of the units.

These cost input-load output and incremental cost characteristics are computed from tests on the equipment and it is very important that these tests be obtained with a high degree of accuracy. An operating factor based on a knowledge of the performance of the unit under normal conditions of operation is applied in order to obtain the true normal operating characteristic of the unit. The amount of equipment and location of equipment operating at the various stations must in all cases conform to the standard system operation reliability, which takes into consideration such factors as physical layout, storms, voltage regulation, and protection of the load.

With the determination of the amount of equipment operating at the various stations any change in system demand will be made on the basis of the station incre-

nental cost curves for the equipment operating to a oint at which it becomes more economical to operate n another set-up. This method of loading for every nomentary change in demand gives a minimum cost or all ranges of load, limits the number of units operating to those required for economy and reliability, and esults in a greater utilization of the more efficient units.

In the case of one large power system during the last ear the generating capacity of the system was increased bout 2 per cent whereas the output delivered by the ewer units was raised 13 per cent. As a matter of fact n that system during the year 1930 considerably more ilowatt hours were generated than in 1929 at a total roduction cost lower than that of 1929.

Table I shows the actual operating results obtained rom several different types of stations. The low heat ate obtained by Station A indicates the possibility of a reater adoption of the mercury steam turbine in the ear future.

River Rouge plant starts operation this year of the very interesting steeple compound 110,000-kw. turbo generator. The initial steam condition is 1,200 lb. at 750 deg. fahr. Live steam reheaters will raise the temperature of exhaust steam from the high-pressure element to 550 deg. fahr. at 80 lb. absolute pressure before it enters the low pressure element. Of particular interest is the fact that this new machine is installed in space originally occupied by two 12,500-kw. turbines and sufficient space will remain for the addition of a second 110,000-kw. unit of the same type at a later date. Two boilers, each having a maximum steam capacity of 700,000 lb. per hour, will serve this turbine.

The Port Washington plant will have one boiler of 690,000 lb. of steam per hr. to operate at 1,300 lb. pressure and initial and reheat steam temperatures of 825 deg. fahr.

In the realm of boilers for pressures above 1,400 lb. there has been no development except in that of size.

TABLE I—RECENT OPERATING RESULTS

Station	Pressure lb./sq. in.	Temperature deg. fahr.	Cycle	Load factor per cent	Period	Heat rate B. t. u./net kw-hr.
A	70	884	Mercury		Dec.-Feb. 1930	10,180
B	1200 350	750	Reheat regenerative	72.9	Oct. 1930	13,910
C	600	725	Reheat regenerative	65.5	Dec. 1929	12,455
D	1250	750	Reheat regenerative	52.0	Oct. 1930	14,091
E	600	725	Reheat regenerative	71.5	Oct. 1930	14,581
F	600	730	Reheat regenerative	62.7	Feb. 1930	13,368
G	400 250	725	Regenerative	54.8	Oct. 1930	16,290
H	400	700	Regenerative	59.3	Oct. 1930	15,712

echnical Developments in Steam-Electric Plant Design

The seven high-pressure stations described in the last eport have been in operation long enough to confirm he results expected from them. Excepting continuing rouble with boiler feed pumps in some of the plants, o unsolved difficulties have been encountered. The nore prominent additions to the list of high-pressure lants within the past two years have been the State ine plant near Chicago, the River Rouge plant of the ord Motor Company in Detroit, and the Port Washngton plant of the Milwaukee Railway and Light ompany.

State Line plant, described in previous reports, was laced in operation in 1929 with a single three-element urbo-generator unit of 208,000-kw. capacity. The nitial steam conditions were 630-lb. pressure and 730 eg. fahr. The extension to the plant now under construction includes two single shaft units of 150,000- and 25,000-kw. capacity respectively. The steam conitions will be 1,200 lb. and 825 deg. fahr., using boilers red with pulverized coal from unit type mills. An nteresting feature in connection with the turbines will e the reheating of steam from the high-pressure cylinder to 825 deg. fahr. at 400 lb. pressure, and its reintroduction into the high-pressure cylinder for expansion to he cross-over pressure of 15 lb. absolute. Reheating ill be done in boilers of the reheat type.

The Benson and Loeffler boilers are now being built in Europe in capacities above 100,000 lb. of steam per hour; three Loeffler boilers, each with a designed output of 150,000 lb. of steam per hour at 1,850-lb. pressure and 932 deg. fahr. have recently been ordered for a plant in Czechoslovakia. The Benson boiler in use at the Langerbrugge plant in Belgium produces 220,000 lb. of steam per hour at 2,270-lb. pressure. An experimental boiler to operate at 3,200 lb. pressure, being installed at Purdue University, will be the first at that pressure in America. Boilers for 1,800 lb. pressure to supply steam to two 6,400-hp. triple expansion engines are now in course of erection at the Philip Carey plant in Cincinnati. The design of European types of high-pressure boilers was reviewed in the 1929 report.

There is some evidence that the average steam temperature in large power plants in this country has increased slightly during the past two years, and the maximum temperature in use is now considered to be approaching 800 deg. fahr. The Langerbrugge plant in Belgium has operated at a temperature of 850 deg. fahr., for 4½ years and in general there is more of a tendency to use extremely high temperatures in Europe than in this country. In certain respects modern European boiler designs lend themselves to the generation of high temperature steam, and the practise of multi-barrel turbines, common in Europe, is also

adaptable to its use. In the United States the Detroit Edison Company has recently put into operation a 10,000-kw. turbo generator at its Delray No. 3 plant, designed to use steam at 1,000 deg. fahr. At the present time the turbine is operating on steam from the station main under 400 lb. pressure and at 750 deg. fahr. For high temperature operation the supply steam will be passed through a separately fired superheater using oil for fuel. The steam main between the superheater and turbine is provided with several types of pipe joints, and other arrangements have been made to note the effect of the high temperature upon the piping, turbine, and superheater, so that the installation constitutes in reality a full scale experimental investigation.

During the past two years the mercury vapor boiler and 10,000-kw. turbine installation of the Hartford Electric Light Company has been perfected to the point where it was available for 82.3 per cent of a period covering 7,520 hours. Excluding causes arising from the use of mercury, the installation would have been available 95.1 per cent of the time. The average thermal rate was 10,310 B. t. u. per net kw-hr. Of the total energy generated, 42.5 per cent was produced by the mercury turbo generator, and the remainder by the steam formed in the mercury condenser.

As a result of the experience at Hartford, mercury vapor units of 20,000-kw. capacity each are being planned for the Kearney plant of the Public Service Corporation of New Jersey and for the power plant of the General Electric Company at Schenectady. The latter installation and an associated steam boiler will be one of the first outdoor steam plants. The mercury vapor pressure will be increased to 125 lb. per sq. in. in these new units, and it is expected that a thermal rate of 8,800 B. t. u. per net kw-hr. will be secured at a load of 20,000 kilowatts on the mercury turbine and with the power developed from the 240,000 lb. of steam per hr. produced at 400 lb. pressure in the mercury condenser.

Higher steam pressures and investigations of troubles resulting from caustic embrittlement have indicated the desirability of boiler drums without seams. Forged drums have been used exclusively for the 1,400-lb. boilers, and lately hammer-welded drums for medium pressure boilers such as the four drum boilers in the James H. Reed Station of the Duquesne Light Company in Pittsburgh, that operate at 400 lb. pressure. The possibilities of fusion welded boiler drums have been studied intensively in the past two years, and "Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers" were published in the March 1931 issue of *Mechanical Engineering*. The Boiler Construction Code does not at present permit fusion welding of parts where the safety of the structure is dependent upon the strength of the weld.

While no boiler installations have been made of larger capacity than those in the East River and Hell Gate plants in New York that were described in the last report, operating experience at the East River plant has shown that loads can be carried on the boilers there considerably in excess of the expected capacity. A unit generation of 1,250,000 lb. of steam per hour has been maintained, the actual operating limit being met in the capacity of the steam piping leading from the boiler unit. A boiler of 1,000,000 lb. per hr. capacity was recently installed in the Kips Bay plant of the New York Steam Corporation on a floor area originally allotted in 1926 for a boiler of half the output. These large boilers are in reality twin-set boilers having two independent water circulating systems and steam uptake connections, located over a common furnace. The largest single boiler to date has a capacity of about 600,000 lb. of steam per hour.

The installation of boilers of large capacity has focused the attention of operating and designing engineers upon the problem of boiler availability. Although in most plants the number of boilers still exceeds the number of turbo generators, boiler outage in many cases impairs to some extent a plant's generating capacity. Protection of the furnace walls with water cooling surface, improved reliability of the coal feeding and burning equipment, as well as of the ash handling apparatus, increased attention to the details of the auxiliary apparatus, and correct boiler water conditions, have resulted in numerous instances of boiler availability equal to that of turbo generators. The first statistical study of this subject on a large scale was directed in 1929 and 1930 by Mr. C. F. Hirshfeld of this Committee, and was published in *Transactions*, A. S. M. E., Vol. 52, No. 27, p. 265. The data compiled covered only a year and there were several other reasons why the statistics were necessarily inconclusive, but they seemed to indicate that the details of design and construction and operating skill are more important in obtaining high boiler availability than such matters as rate of output per unit of surface, type of fuel, and method of firing. The average availability factor appeared to be between 84 and 90 per cent.

During the period being reviewed, the point of major technical interest in connection with the pulverized coal method of combustion has been the long-time comparisons in the same plant of the unit and bin systems. No generally accepted opinion regarding their merits has been reached. Both systems were installed in the Deepwater plant, New Jersey, where it has been reported that the unit method of firing gave a higher efficiency but a lower reliability. Other comparative studies have been recently published for central stations in Chicago and St. Louis.

Experimentation has continued with the slag tap type of furnace for pulverized coal firing, and its use has been extended. The major difficulty has been the gradual expansion in a horizontal plane of the furnace floor, with consequent bulging of the furnace walls. This results from penetration of the hearth bed by the molten slag, through cracks formed when the furnace is cooled during boiler shutdowns.

The size and total fuel burning capacity of underfeed

tokers continue to increase, and steam outputs per oiler of 500,000 lb. per hr. are now possible with toker firing. There has been only a foot increase in he maximum width of stokers in the last ten years, ut the length has been increased from about 13 ft. to 6 ft. 7 in. The largest underfeed stoker in this country s now being installed in the Hudson Avenue plant of he Brooklyn Edison Company, and will be 26 ft. 7 in. ong by 26 ft. wide, with a grate area of 694 sq. ft. Stokers of this size have been made possible by extensive ooling of the furnace walls by water cooled surface, mproved coal feeding and distributing mechanism, and etter control of the air distribution to the several parts f the grate surface and ash pit. In come cases auto- natic control of the air distribution has been installed. Rotary ash dischargers are almost standard for the arger size of stokers.

Although the fuel burning capacity of stokers per foot f width has been greatly increased, there has been no ncrease in the rate of combustion per square foot of otal grate surface, which is limited by the possibility f clinkering and the blowing of coal from the firebed. Neither has there been any modification of the fact that he combustion rate depends upon the type or burning haracteristics of the coal burned. Maximum rates of 0 to 70 lb. per sq. ft. for 10 hour periods have been naintained with good quality eastern coals; 50 to 60 lb. vith coals from the central field. Slack coal reduces the nax mum rate to the neighborhood of 40 lb. per sq. ft. With all coals an increase in the combustion rate results n an increased loss from incomplete combustion, cin- ers, soot, ash pit, radiation and unaccounted for losses, n some reported tests these losses reaching a value of 0 per cent.

The limiting temperature for preheated air with nderfeed stokers seems to be in the neighborhood of 50 to 400 deg. fahr. Although some installations have ttempted to use higher temperatures, it has been ound that the stoker maintenance has been adversely ffected.

The installation of large turbo generators has con- nued although no units have been projected larger nan those mentioned in the last report. The largest nachines now on order are two 160,000-kw. units for ne Hudson Avenue plant of the Brooklyn Edison Company. It is noteworthy that all of the turbo enerators except one, that are now on order in sizes reater than 100,000 kilowatts, are of the tandem com- ound type. The exception is the 110,000-kw. high- ressure vertical-compound machine for the Ford Motor Company. The development of generators of rge capacity was an essential to the use of tandem- ompound turbines.

The record in capacity for single cylinder turbines perating at 1,800 rev. per min. is now carried by two 0,000-kw. turbo generators in the Charles R. Huntley ation of the Buffalo General Electric Company. team supply to these units is at 435 lb. and 750 deg. hr.

In the field of high-speed turbo generators, single cylinder condensing units are now in operation in the United States up to 10,000-kw. at 3,600 r. p. m., and tandem-compound units at the same speed up to 15,000 kw. A 15,000-kw. single-cylinder condensing unit of English manufacture has recently been installed in Canada and the C. A. Parsons & Company are willing to build single-cylinder units of 25,000-kw. capacity to operate at 3,600 r. p. m.

Intensive study in turbine design is being made in connection with the use of higher steam temperatures. This problem as well as that of blade erosion is a matter of metallurgy, and the developments to date indicate that it will soon be possible to operate turbines at initial steam pressures above 500 lb. without the necessity of reheating. At the present time a 60,000-kw. unit has been built to use steam at 650 lb. and 825 deg. fahr., and illustrates the simplification and turbine arrangements that will be possible when higher steam temperatures are available.

High-Voltage Generators

There has been a significant demand for generator units of larger and larger capacities, and while this has possibly been the condition since the beginning of power station construction it appears to advance by periods with the most recent one occurring within the past five years. With an increase in generator capacity the designing engineers have been faced with the problem of providing suitable and reliable insulation, conductors, supports, and terminals both internal and external to the machines. Machines of larger capacity for a given voltage mean greater currents. Greater currents mean larger conductors, and consequently greater weights to support normally and greater stresses to provide for at times of short circuits. With the greater currents other external difficulties also arise, such as the provision for the installation of large cables if the power is taken away in underground cables, the reduced carrying capacity of the cables if many are required in restricted spaces, and the provisions necessary to nullify the effect of the sheath voltages. Consequently there has been a very natural trend to higher generator voltage and to multiple-winding machines to reduce the amount of current per conductor.

Unless it is necessary to consider generation at a pre-established voltage and the distribution problems connected therewith, in other words, if generation alone, is to be considered, the most economical voltage usually increases slightly with the increase in the size of the unit. From the generator manufacturer's standpoint, for generators of 100,000 kw. or more, voltages in the neighborhood of 16,000 to 18,000 volts are reported to result in the most economical design. In some instances, economics dictate machines within this range of voltage with transformers for stepping up to the desired transmission voltage, so that, where the generator voltages are not well established, it might be said that for machines above 100,000 kw., the present

trend is toward the use of multiple-winding machines with transformers or auto-transformers, rather than to higher voltage machines. The trend will no doubt continue toward multiple-winding machines until the point in capacity is reached when it will prove more economical to increase the voltage.

Some attempts have been made to standardize on generator voltages above 13,800 volts, but since the introduction of successful multiple-winding machines, the study and demand for higher standard voltages has not been so insistent, and may be said to be dormant for the time being. In other words, the double-winding design has made it possible to increase the capacity without increasing the voltage, and to postpone the day when it will be necessary to go to higher voltage. It is not at all unlikely that in the future, generators will be built with more than two windings. The principal difficulty with more than one winding, is in finding sufficient space at the terminals of the machine windings, to install potheads and make connections with satisfactory clearances.

Within the past three years there have been installed in the territory adjacent to Chicago, and there are now in operation, seven 22,000-volt generators with a combined generating capacity of 474,000 kw., ranging in size from 52,500 kw. to 105,000 kw. Additional 22,000-volt generators totaling 432,000 kw., and one 18,000 volt, 115,000-kw. generator are on order for this territory, to be installed during the years 1931-1932.

Outside of the above there have been but four steam-driven generators placed on order or installed recently in this country for voltage ratings above 13,800 volts, namely:

Two 160,000-kw., 16,500-volt units for the Brooklyn Edison Co., and

Two 94,000-kw., 16,500-volt units for the Southern California Edison Company.

Abroad, the outstanding recent high-voltage installations which will be watched with considerable interest are the two 33,000-volt, 25,000-kw., 3,000-r. p. m. generators at Brimsdown, England, and the 36,000-volt, 25,000-kw., 3,000-r. p. m. generator at Langerbrugge, Belgium.

Switch Structures, Switching, and Control

The housing of major switching in both congested and open localities is receiving much study, particularly new installations, because of the advent of metal-clad switchgear. There has been a marked increase in and trend toward the use of metal-clad switchgear in place of indoor cell type and outdoor open type bus structures. Many hundred indoor and outdoor type metal-clad combined switch and bus units of American design are now in service, some with air and some with oil-filled metal enclosed bus compartments.

The first installation in this country, and possibly in the world, of high-voltage outdoor metal-clad switchgear was the 33-kv. substation of the Public Service Company of Northern Illinois, at Wheaton, Illinois. This has been in service since March 1928. Since then there have been many other installations which embody improvements in design and manufacture. This type of switchgear can now be obtained in practically all capacities for which circuit breakers have been developed, including 132 kv. One 132-kv. installation is now being made. The earlier large units involved a considerable amount of field assembly. The latest designs permit complete factory assembly and testing of very large capacity units, such as a full double bus section for one circuit, complete with instrument transformers, buses, etc., for breakers of 22-kv., 3,000-amperes, 2,500,000-kva. interrupting capacity. These units are shipped completely assembled and oil filled thereby entailing a minimum of field assembly and installation work, and avoiding the necessity of drying out, reconditioning, etc., by purchaser.

In the case of several generating stations it has been found that an outdoor oil-filled metal-clad switchgear structure could be installed cheaper than an isolated or separated phase indoor cell structure if the cost of the building is taken into consideration; in some cases a saving as high as 20 per cent has been indicated. Other companies report the reverse where installation conditions are different. One company has proved by actual cost data that for 33-kv. substations the total over-all cost of metal-clad outdoor switchgear erected and ready for service, compares favorably with that of the conventional open type formerly used. This latter comparison, however, would not yet hold for all conditions and localities.

Additional advantages to be gained from complete factory built equipment are the saving in space, the salvage value in case of replacement or rearrangement, and the much greater safeguards to operators and service.

There is a growing demand for faster operation of circuit breakers in case of fault. The manufacturers have made considerable progress toward meeting this condition in the design of circuit breaker operating mechanisms and contacts and methods of extinguishing the arc as well as in the high-speed relay designs. Tests have shown repeated operations where the arcing time was as low as one to two cycles. Large breakers are now available with a conservative over-all time rating of eight cycles. In view of these developments it is quite possible a more severe duty cycle than the 2-OCO may be considered for the rating of oil circuit breakers.

The interest indicated in locating equipment outdoors is not confined entirely to switchgear. There are a few instances where large rotating units have been installed outdoors, and the subject is being given much study.

There has been an increase in the tendency toward the use of steel switchboard panels and the use of hinged panels or cubicals. The desirability of smaller switchboards in the larger power stations and substations is also receiving attention. Various attempts

have been made to use miniature equipment, and a smaller number of items, and combination units of instruments and relays. At the same time there is a growing demand for more relays and instruments for one purpose or another. The supervisory system of control seems to be arousing more and more interest as a means of condensing or consolidating the control of a large number of circuits within the convenient reach of a single operator.

The so-called distance relays are becoming more popular. The automatic synchronizing, automatic frequency, and automatic load division control are receiving more attention. Although the first has been available for a number of years, the latter are more recent developments and it is quite possible that the demand for both may grow.

If the predictions indicated in recent announcements with reference to vacuum tube developments, such as the "thyratron," may be anticipated, we are about to see some very wonderful and radical changes in the entire scheme of station control, switching, transformation, transmission and control station design in general. To what extent and how rapidly this may take place is at present problematical. The possibilities we must admit, however, are tremendous. Already there have been some novel commercial applications and very promising laboratory tests extending over a considerable period.

A new type of adjustable-speed control for a-c. motor drive is now available, permitting practically a straight line speed curve with infinitely small steps from zero to maximum. The drive can be installed at nearly the same cost as the drives previously used. The method of control permits high efficiency which in some cases shows a considerable saving over any other type of control. The drive will maintain constant speed regardless of load, is simple, permits the use of standard electrical design features, and to a considerable extent, standard machine parts. To date the service applications have been confined to boiler draft fans and boiler feed pumps, but the drive is adaptable to many other services where fine speed adjustments, and simplicity of operation with high efficiency, are important factors. Thirty-five of these equipments were ordered in 1930, some of which have now been in service for several months. For those who are not familiar with the 'Rossman Drive" system it may be of interest to state it consists primarily of an induction motor of standard design, except that the mechanical construction is modified to permit what would be the stator to revolve. This revolving stator is connected by texrope or other means, to a smaller standard d-c. machine fed from a standard motor-generator set or other d-c. source. The speed of the small d-c. machine is controlled by adjusting the voltage impressed on its armature by the generator of the motor-generator set. This may or may not be supplemented by field control. By varying the speed and direction of rotation of the d-c. machine, the load may be driven at any speed within the design range.

Factors at Present Affecting Hydroelectric Development

The increasing attention directed to the large-scale hydro developments on the Colorado and St. Lawrence rivers by governmental agencies is perhaps a new factor influencing the trend of hydroelectric installations. At the same time the federal waterpower licensing policies are being questioned and subject to criticism by both private and political interests, and both have been coincident with severe drought during the past two years in many parts of the country. The complementary value of hydro and steam power sources on systems supplied mainly by hydro has been fully realized, and the principal hydroelectric systems on the Pacific Coast, in the southeastern states, in New England, and in the vicinity of Niagara Falls, have either put into operation during the last two years steam plants of large ultimate capacity or have affected large capacity ties with existing steam plants in adjacent territory. The recent availability of low cost gas and oil fuels in the West, and the advances made in the thermal efficiency of large boilers and turbines, combined with their attractive investment costs, are causing a pronounced predominance there of steam-electric installations that will continue for an unknown period. In the East and South the necessity of steam reserves for low-flow periods has accelerated steam expansion programs. At Niagara the entire water diversion permitted under the existing treaty is utilized and the load growth necessarily must be assumed by steam generation.

Type of Steam Plants on Hydroelectric Systems

A marked similarity in certain design features is noticeable in all of the new steam plants supplementing power systems hitherto dependent upon hydro generation. Gas and oil are the outstanding fuels in the West, while in the East pulverized coal exclusively is fired. Boiler capacities range from 400,000 to 550,000 lb. of steam per hr. at pressures between 425 to 475 lb. per sq. in. with the exception of one plant on the Pacific Coast operating at 1,300 lb. per sq. in. Turbine capacities vary from 40,000 kw. up to 100,000 kw., and one to three boilers are installed per turbine, the usual number being two. The selection of pulverized coal firing appears to be made for reasons other than the emergency starting of boilers; and in fact extra facilities for standby operation of turbines and boilers are provided in only one of the recent plants, which operates on a system where steam generation will be a minimum yet service demands require continuous availability of the steam-electric generator.

General Features of Recent Hydroelectric Development

No hydroelectric plants of unusual total capacities have been put into operation during the past two years, although there have been one or two new records for

turbines of large physical dimensions, and the three 49,000-hp. Francis units in the Waterville plant in North Carolina surpass in capacity all previous units of that type operating under high heads. An unusual construction procedure was adopted for the Chute-a-Caron plant on the Saguenay River in Canada. The preliminary drawings for the Boulder Dam plant on the Colorado River reveal no unusual features except the height of the dam and the contemplated power capacity. The Spier Falls plant on the Hudson River is an interesting example of rehabilitation and design investigation by means of model tests. In fact the increasing use of model testing, and its application to the design of the propeller type turbine wheel, constitute the outstanding technical advance in this country in hydroelectric practise during the past two years.

Propeller Turbine Development and Model Testing

Notable installations of propeller turbines of the fixed and manually adjustable blade types were in operation or approaching completion in 1928, and one small capacity wheel of the automatically adjustable type, the Kaplan turbine, was in the course of erection. Since 1928 there have been numerous installations in America of small capacity Kaplan type propeller turbines, that have been designed and installed under European licenses. The Kaplan turbine was first developed in Europe where there are now some large capacity wheels in operation. It is essentially suitable for low-head developments, being used for heads up to about 70 ft. European designs of the fixed blade and Kaplan turbines have been based upon extensive model testing of the turbine wheels as well as of the associated inlet casings and draft tubes.

One of the principal objects of testing models of propeller type wheels has been to determine the limiting conditions of cavitation, for which adjustable draft head conditions are required in the test laboratory. Cavitation, or the formation of bubbles of vapor and air in low-pressure areas adjacent to the runner surfaces, causes a drop of wheel efficiency, but its most prominent effect is the rapid disintegration of the runner material. Cavitation pitting had been encountered in this country with Francis type wheels under certain conditions of specific speed and draft head, and an amount of field experience has been accumulated by which proper operating conditions can be selected for Francis wheel installations. One of the chief advantages of the propeller turbine is the higher specific speed that is possible, but as field data were lacking for such operation, it was considered essential in Europe to determine the optimum installation conditions in advance of construction by means of cavitation testing. Following such investigations propeller turbines of record dimensions, horsepower, and water discharge capacity have recently been installed in the Ryborg-Schworstadt and Kembs plants on the Rhine River in Europe. Pertinent data about these plants are as follows:

Plant	Ryborg-Schworstadt	Kembs
Type of runner	Kaplan	Fixed blade propeller
Number of units	4	5
Head in feet	35	54
Turbine rating-horsepower	35,000	36,000
Water discharge-cu. ft. per sec	10,500	6,800
Rev. per min	75	94
Runner diameter-inches	276	220.8

Cavitation laboratories have been built during the past year, one or two in the United States and one in Canada, for the investigation of design problems concerning propeller type wheels. The construction of a national Federal hydraulic laboratory has also been recently authorized; model testing has been done extensively at one of the technical colleges in the United States for the design of dam spillways, water courses, and turbine settings, and two or three other colleges and individual companies have done a certain amount of such investigation. The first large plant in this country to install automatically adjustable blade propeller turbines is now being built at Safe Harbor on the Susquehanna River in accordance with data obtained from cavitation and wheel setting tests. Six turbines having a rating of 42,500 hp. each at a gross head of 55 ft. are being installed initially. The wheels will have a diameter of 220 in., a water discharge of 8,000 cu. ft. per sec. at rated head and output, and will operate at 109.1 rev. per min.

Briefly described the Kaplan turbine consists of a propeller, or axial flow turbine, whose blade angle is controlled by the speed responsive governor that controls the turbine wicket gates. Separate servo-motors are provided for operating the blades and gates, and a cam is used in the governing mechanism to direct the movement of the runner blades according to the movement or position of the wicket gates. The servo-motor for operating the runner blades forms part of the turbine shaft, and is usually located just under the generator coupling. The links and crank arms for moving the blades are enclosed in the runner hub.

By automatically maintaining the correct relation of blade position to gate opening, the peak efficiencies of a series of propeller wheels each having the proper blade angle for a particular turbine load, are secured, with the result that the efficiency-horsepower curve of such a turbine is quite flat compared to similar curves for fixed blade propeller and Francis turbines, the efficiency at low loads being materially higher. Another feature of the Kaplan turbine is the overload capacity possible by adjustment of the blades, which is of particular value in times of reduced head during high river stages. It is expected that the efficiency of the Safe Harbor turbines will exceed 85 per cent over two-thirds of the load range, and to equal 90 per cent or better for the third quarter of the unit capacity.

Rehabilitation of Hydro Developments

The 57,000-hp. unit recently added to the Spier Falls plant on the Hudson River, New York, exemplifies two distinct tendencies in hydroelectric practise, illus-

rating in addition to the use of model testing as a lesign adjunct, the recognition of the value of an over-leveloped plant for supplying peak-load capacity and he benefit derived from a storage resource by a run-of-iver development. At full load the wheel discharge s 7,000 cu. ft. per sec., making it the largest Francis-ype runner to date in this respect as well as in physical limensions. The minimum regulated flow of the Hudson River at Spier Falls is 3,000 sec.-ft., and 5,000 ec.-ft. for 50 per cent of the time. Both the turbine nd generator approach record sizes in physical dimen-ions, the total weight of the rotating element being bout 450 tons. The generator stator is 37 ft. in liameter, and the diameter of the scroll-case entrance f the turbine is 26 ft. The unit operates at a speed f 81.8 rev. per min. under a head of 81 ft. Tests of a nodel of the forebay and intake structures enabled he best forebay outline to be determined with regard to mount of necessary excavation balanced against the ead loss in forebay and intakes. The tests revealed hat the area of the intake gates could be economically educed 20 per cent, and this was of special value be-ause the water passages are so large that they gave ise to structural design difficulties. It is reported that he tests resulted in a saving equal to ten times the ost of the tests.

High Head Plants

The Waterville plant of the Carolina Power and Light Company on the Pigeon River in North Carolina as an unusually high operating head, 840 to 750 ft., or a hydro plant in the eastern part of this country. There are three 49,000-hp. reaction wheels in the plant, operating at 400 rev. per min. and these are of record note for their capacity at such a head. The six-mile unnel from the reservoir created by the dam to the power house is unprecedented even in the notable high ead installations on the Pacific Coast. The use of ast steel butterfly valves of 9 ft. diameter under a otal head of 840 ft. located in the penstocks near the power house, has been reported quite successful, and s an advance in the size of such valves under high ressure. Johnson valves are also provided in the enstocks where they enter the plant.

The record for large capacity high head Francis vheels will shortly be established in the Diablo plant f the City of Seattle, where two turbines of 90,700-hp. apacity each, to operate under a head of 327 ft. are eing installed. The turbines will have cast steel croll cases and concrete elbow draft tubes.

The record head, however, for Francis wheels occurs n a European plant, the Bringhausen plant in Germany, vhere four 40,500-hp. horizontal-shaft Francis turbines re being installed to operate under a head of from 950 o 1,000 ft. This is a pumped storage development nentioned later.

Large Scale Hydro Developments

The Beauharnois development on the St. Lawrence River in Canada is notable for the ultimate capacity being planned when the entire flow of the river passes to the power house through the combined navigation and power canal connecting two of the lakes on the flow line of the river. The initial section of the plant will contain ten 50,000-hp. units, to operate under a head of 83 ft. The final capacity will be 2,000,000 horsepower. The construction of the canal between lakes St. Francis and St. Louis, which will be 15 miles in length with a width of 3,000 ft. and a depth of 27 ft. is outstanding because of its magnitude rather than any engineering difficulties.

Another plant that illustrates the scale of development possible on some of the rivers in Canada is the Chute-a-Caron plant on the Saguenay River where four 65,000-hp. units have been installed as the initial step of the future Shipshaw plant of 1,000,000 horsepower. The Chute-a-Caron dam will serve to divert the river for later construction of the Shipshaw plant, but because the head at Chute-a-Caron is only 151 ft. as contrasted to that of 205 ft. at the parallel site, the Chute-a-Caron plant will be operated in the future only during river flows sufficient to supply both plants. The difficulty of construction in the gorge of the Saguenay River is thus being solved by the step-by-step development at the two neighboring plant locations. The river was diverted in a unique manner for the construction of the Chute-a-Caron dam by toppling a concrete cofferdam 92 ft. long into the swiftly flowing current, which caused the flow to pass into an artificial channel previously prepared. The action of the concrete monolith weighing 11,500 tons was accurately predicted by means of model tests.

Storage Developments

The largest hydroelectric plant in New England has been recently completed at Fifteen Mile Falls on the upper reaches of the Connecticut River, in conjunction with the first 220-kv. transmission line in New England. The plant is designed for four 53,000-hp. units at 175-ft. head, and is the first development at two nearby sites which will eventually have a total combined rating of 300,000 horsepower. The completion of the second plant will create a reservoir for regulating the river flow not only for the plants at Fifteen Mile Falls, but also for the plants at Bellows Falls and Vernon, farther down the river. The 220-kv. line carries the output of the plant to a distributing point in the vicinity of Boston.

The Osage plant at Bagnell, Missouri, now approaching completion, will contain six 33,500-hp. units operating under an average head of 90 ft. Without storage this plant would not be feasible since the river flow varies from 324 to 110,000 cu. ft. per sec. with an average of 10,500 sec-ft. The dam will create a reservoir 95 sq. mi. in area having an impounded volume of 87 billion cu. ft., so that the flow of the river will be completely equalized with a draw-down of 30 feet. The average yearly energy available will be about 400 million kw-hr. The Osage plant is also a late example of the omission of a superstructure over the

generator bay, the station crane having one gantry leg while the other end of the crane rests on top of the outer wall of the electrical bay which is placed over the penstocks between the dam bulkhead and the generator bay. Low metal housings are provided over the tops of the generators.

The Saluda storage development in South Carolina, described in the last report, was placed in operation last year and is notable for its reservoir capacity of 102 billion cu. ft.

Outdoor Type Plants

The omission of the generator room superstructure continues both for small plants of a single unit and for plants of large installed capacity. Generator designers are predicting that the flexibility of design now possible with fabricated construction, and the latitude permissible in the layout of auxiliary power and excitation systems, will lead to the arrangement of generators to conform to the design of the power house, and that the logical outcome may be the wider use of outdoor generator designs.

Pumped Storage Plants

No installations of pumped storage plants in America have followed the completion of the Rocky River plant in Connecticut, although the use of pumped storage continues popular in Europe where electric system peaks are of shorter duration than in this country. One illustration is the Bringhausen plant on the Weser River in Germany, now under construction, which will contain four combination pump and waterwheel units, each consisting of a 40,500-hp. Francis type horizontal turbine coupled directly to a 36,000-kva. generator, on the other side of which is a clutch for coupling to a 100,000-gal. per min. pump requiring 29,000 hp. for pumping. The plant is connected to an upper reservoir at an elevation 1,000 ft. higher by two penstocks 3,250 ft. in length. The water to be pumped to the reservoir amounts to 26,800,000 cu. ft., from which 500,000 kw-hr. will be generated. Power for pumping during off-peak hours is obtained from interconnected steam plants and other hydro plants on the system.

The horizontal coupling of a pump and a turbine with a generator and/or motor seems to be the preferred arrangement for pumping plants in Europe, and is in contrast to the Rocky River plant layout of pumping units with individual drive motors separate from the main turbine and generator, all of the equipment being of vertical type. The Rocky River pumps which are the largest high-head pumps in this country, have a volute discharge casing without diffusion vanes, and are of the single inlet type. On test the Rocky River pumps showed a maximum efficiency of 91.7 per cent; the efficiency expected by the designers of the German pumps is approximately 80 per cent.

Hydroelectric Generator Developments

There has been a widespread adoption during the past two years of fabricated steel plate construction of both stator and rotor of vertical waterwheel generators, in place of the use of castings formerly standard. Such generator construction of welded steel plate is lighter in weight, is considered to be more reliable mechanically, and is more adaptable to design arrangements. There has been an increased use of the umbrella, or overhung type of generator rotor, in which by means of downwardly curved rotor arms the centerline of the rotor rim or pole faces is brought below the horizontal centerline of the hub. By locating a combined guide and thrust bearing, sometimes of the spherical type, just below the rotor hub, a very material reduction in over-all generator height is secured. The use of rolled steel plates and fabricated construction for the stator has also facilitated the arrangement of ventilating ductwork in connection with the water tube air coolers that are now used very largely for generator cooling. Other advantages of fabricated plate construction are quicker manufacture and possibility of design for shipment without restriction by permissible weights or clearances.

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The subcommittee wishes to express its appreciation of the helpful suggestions received from the main body of the Power Generation Committee.

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†Hydraulic Division.

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Power Transmission and Distribution

ANNUAL REPORT OF COMMITTEE ON POWER TRANSMISSION AND DISTRIBUTION*

THE Committee has continued with its work during the past year through a number of subcommittees organized as in preceding years. All of these subcommittees have been very active in studying the problems in their respective fields, and in promoting investigation work and the preparation of papers for presentation before the Institute. The reports of the work of the several subcommittees follow.

Subcommittee on Distribution

One of the most interesting developments in connection with the distribution of electrical energy during the past year has been the practical application of the network principle to primary distribution. The economies and improvements to service which are made possible through the adoption of the low-voltage network have been so clearly demonstrated by the generally satisfactory performance of the many recent installations, that a wider application of the principle is not surprising.

At the present time there is being installed a 4-kv. primary network in Pittsburgh, Pa. This will serve a residential district of comparatively low-load density which was previously served by an overhead radial system.

The application of the network principle to 4-kv. service for such an area requires certain radical departures from the designs which have become fairly well established for distribution. Since underground construction in the areas of low-load density is not usually justifiable from an economic viewpoint, overhead construction must be used. The primary network deserves careful consideration from the standpoint of economy, reliability, and system planning in handling loads in areas not readily adaptable to low-voltage network distribution.

The past year has seen a continued application of vertical network distribution in large office buildings. This type of distribution has been used in a number of large cities including New York, Pittsburgh, and San Francisco. At the present time several features of design have not been settled. These features are being given consideration and it is expected that with the extended application of the vertical network principle a better understanding of them will result.

The question of secondary faults on low-voltage a-c. networks is still being discussed at length. There is a feeling among some engineers that the problem is not radically different from that encountered on the d-c. network. Others feel that short-circuit currents available are generally less and the condition is therefore more difficult. The use of buried cable has also been studied and tests made which will be reported in the near future.

Subcommittee on Lightning and Insulators

Past Year's Activities in Investigation Work

The activities in the field of lightning investigation during the past year have been carried on by means of:

1. Field investigation of natural lightning.
2. Field investigation with artificial lightning.
3. Collection of operating data on lightning performance of lines.
4. Theoretical analysis and coordination with the past lightning data.

In the field investigations, use was made of cathode-ray oscillographs, klydonographs (and surge recorders), surge indicators, lightning intensity recorders, direct-stroke recorders, and artificial lightning generators. This year the field investigation was extended to include a wood-pole line on which was recorded lightning voltages in the order of 5,000,000 volts.

By concentrated efforts in the field with the artificial lightning generator, a vast amount of knowledge has been gained on the effect of tower footing ground resistance, counterpoises, effect of normal voltage in sustaining a power arc in the presence of lightning flashover of a line, and particularly on the operation of the lightning arrester.

The behavior of traveling waves at the junction of cables with overhead lines was further studied by the use of the artificial lightning generator with particular attention to the application of lightning arresters.

Extensive use was made of the lightning (direct) stroke recorder and our knowledge in regard to the

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current in direct strokes amplified, and made more definite.

The cathode-ray oscillograph application was modified to trace the history of a natural lightning wave over a period of some 2,000 microseconds, in addition to recording the initial characteristics of the waves.

Surge indicators were used for the first time, although mentioned in last year's report. These definitely established the fact that a lightning flashover of a transmission line can take place without sufficient follow-up current flowing to trip out the line.

The past year has brought out some intensive study of a theoretical nature on the lightning problem dealing with the mechanism of the lightning stroke and the subsequent surges which may appear on a transmission line. Both the direct stroke and induced stroke have been analyzed and the conclusion pointed out that only direct strokes appear to have consequential effect on the highly insulated lines, while medium and lower insulated lines will be affected in an increasing order by induced strokes.

Results of Last Year's Work

It is impossible here to point out in detail all the results of last year's investigation. There are, however, some outstanding accomplishments, among which the following are cited.

1. The effectiveness of ground wires in reducing lightning voltages and line outages has been further demonstrated.

2. The value of low tower footing resistance in lessening the effects of lightning voltages has been shown.

3. Currents in the lightning stroke in the order of from 50,000 amperes and upwards have been indicated.

4. Counterpoises at a tower footing, even although of comparatively short length are beneficial in reducing the lightning voltage to which a line may be subjected.

5. Lightning sparkover of a line can take place without power follow current.

6. Lightning voltages of both direct and induced stroke origin appear to be present on transmission lines. It is not known in what normal insulation and voltage range the induced voltage ceases to be a factor in line flashover.

Insulation Coordination

In order to coordinate insulation on a lightning basis, its lightning characteristics must be known. Whether these are secured on a single impulse wave or voltage time lag basis, a standard test method must be agreed upon by all who supply this type of data. The Committee has this matter well in hand at the present time, with the probability that an agreement will soon be reached by all actively engaged in this work whereby a group of two or more preferred waves will be used for securing this type of data.

Insulator Flashover Values.

It has been known for some time past that discrepancies have existed in 60-cycle flashover values assigned to insulators of practically the same physical dimensions. The cause for these different flashover values has been traced to a variation in humidity conditions at the time and place of test. A great deal of experimental work has been done on this problem, and it is expected the information obtained will soon be made public through a group of papers before the Institute.

Subcommittee on Interconnection and Stability Factors

In order to coordinate the work of the Power Generation Committee, the Protective Devices Committee and the Power Transmission and Distribution Committee in the field of interconnection and system stability, there has been formed a Joint Interconnection Subcommittee. This Subcommittee was organized during the year and has arranged several sessions of interest in the field of transmission and distribution. These include the session on System Grounding at the Pittsburgh Meeting in March 1931 and the session on System Interconnection for the Summer Convention of 1931. In addition, plans are under way for a symposium at the Winter Convention of 1932 on the subject of Machine Characteristics and System Stability. In last year's report mention was made of the organization of a Subject Committee on Definitions of Terms Used in Stability Investigations. The work of this Subject Committee is now substantially complete and it is planned to present it as a paper at the Winter Convention in 1932.

Subcommittee on Cable Developments

This year has witnessed the continued practically universal use of shielded cable (type H) for all three-conductor high-voltage cables. Other tendencies are the increased use of oil-filled cables, the use of super-calendered paper, a great increase in the use of non-metallic armored cables for direct burial in the ground for low-voltage work, and the use of steel-wire armored, non-leaded cables for submarine service and for vertical distribution cables in high buildings.

The Following Cable Installations May Be Noted:

1. A second circuit, 175,000 kva. (winter rating), of single-conductor 132-kv. oil-filled cable about 6 miles long by Commonwealth Edison Co. in the same conduit bank as their first circuit. The new circuit has 1,100,000 cir. mils conductors as compared with the 600,000 cir. mils previously used. The larger conductor size is made commercially feasible by insulating sleeves and grounding devices to eliminate sheath losses. Due to the many improvements in accessories and technique, the net result was that the investment cost per kva. of capacity is less than one-half the cost of the first line.

2. Two lines of single-conductor 600,000-cir. mil 32-kv. cables each three-quarters of a mile long stalled by the Commonwealth Edison Co. one 00,000 kva. rating) similar to the cable of paragraph 1 ove, and the other (95,000 kva. rating) with novel atures of oil channels cut in the interior of the lead eath as well as an oil channel in the conductor, a mple and small stop-joint, making it possible to have very joint a stop-joint, which joint is practically a ctory-made and factory-tested joint.

3. The Deepwater installation of the United Gas mprovement Co. across the Delaware River consisting two 60,000-kva. circuits (and two spare cables) of ngle-conductor 750,000-cir. mil 75-kv. solid type able manufactured and installed in single lengths each bout 4,000 ft. long. These are the first 75-kv. sub- arine cables and longest lengths of power cable ever anufactured.

4. Two circuits rated at 55,000 kva. each of single- nductor 750,000-cir. mil 75-kv. solid type submarine able of the Union Electric Light and Power Co. of t. Louis across the Mississippi. The cables were made nd installed in single lengths of about 2,800 ft. each.

5. An installation of five three-conductor 48,000- va. 66-kv. oil-filled cables by the Union Gas and lectric Co. of Cincinnati. This is the first three- nductor 66-kv. oil-filled cable, and is buried direct the ground. The conductor size is 500,000 cir. mils ctor, insulated with 0.40 in. impregnated paper and ielded. The cables are made in single lengths 1,300 . long, thus avoiding joints, and are steel-tape armored bles buried directly in the ground.

6. Three commercial installations have been made uring the year of three-conductor 33-kv. to 35-kv. l-filled cable, although the amounts were rather nited. These installations were made by the city of os Angeles, the Staten Island Edison Co., and the yracuse Lighting Co. All three installations were ade with three-conductor type H cable with oil annels in the filler spaces. A novel feature was the ree-conductor positive stop-joint by the city of Los ngeles, and also the fact that a large installation of ble with oil channels in the filler spaces including a ore viscous oil was installed by this company, who ter installation replaced the oil in the channels by l of the type used in oil-filled cables.

7. An experimental installation of single-conductor 32-kv. oil-filled cable by the Commonwealth Edison o. of Chicago in cooperation with two manufacturers, ch of whom supplied 1,000 ft. of 450,000-cir. mil or 00,000-cir. mil cable insulated with 0.40 in. paper nd 1,000 ft. with 0.50 in. paper. The purpose of this periment is to study the limiting stresses and tem- ratures in oil-filled cable for present and future ltages.

8. An experimental installation of single-conductor 2-kv. cable by the Public Service Electric and Gas o. as a continuation of their 1927 experiment studying e possibility of "solid type" insulation for 132-kv. service. The installation consists of three cables each of 500,000 cir. mils and 1,000 ft. long, two supplied by one manufacturer and one by another. Each manufacturer supplied a length of solid-type cable. The third cable is of an intermediate or hybrid type, using oil intermediate in viscosity between that of an oil-filled cable and of the usual type of cable, thus greatly facilitating installation methods while sharing in part the operating advantages of an oil-filled cable.

The Subcommittee on Conduit and Manhole Temperature of the N. E. L. A. Underground Systems Committee has standardized on conditions and constants for calculating current-carrying capacity. This standardization has made it possible to calculate current-carrying capacities of cables covering a large range of sizes and conditions. These tables of carrying capacities will be published by the Underground Systems Committee, and should prove of great value to the industry.

Subcommittee on Steel Transmission Towers and Conductors

The Subcommittee on Steel Transmission Towers and Conductors was organized to assist in the standardization of steel transmission towers and conductors by clarifying the problems associated with their design and application, by papers prepared by recognized authorities on these subjects and presented before the Institute.

The work of the Subcommittee has been divided into three groups, each of which is responsible for one of the following subjects:

I—Towers.

II—Clearances and Electrical Characteristics.

III—Conductors.

During the past year, four meetings of the Subcommittee have been held, together with some additional meetings of groups within the Subcommittee.

An addition to the clause of the N. E. L. A. specifications on uplift of tower foundations and a recommendation for a straight line compression formula for the N. E. L. A. specifications is in course of preparation. Consideration is being given to elimination of the term "factor of safety" by substituting therefore "per cent overload." Contact is being maintained with the A. S. T. M. on its investigation of embrittlement of hot dipped, galvanized steel.

It is proposed to recommend that the 60-cycle flashover be the basis for clearance of the tower under winter or heavy loading conditions and that lightning flashover be the limit for summer or light loading conditions. The width of the right-of-way is to be limited by similar conditions.

Intensive study is being given to the vibration of conductors. Efforts are being directed principally to the coordination of experimental work being done by widely separated investigators, including California, Texas, Illinois, Michigan, Ontario, England, and Australia. A bibliography is being established as an adjunct to this work.

The present membership of this committee, including

the chairman, is now twenty, with five men in Group I, six men in Group II and eight men in Group III.

It is felt that the work of this subcommittee is now progressing smoothly and during the next year, concrete results can be shown as the result of its activities.

Conclusion

For the sake of brevity, this year's report excludes the bibliographies of papers which appeared in last year's report. It is planned to include such bibliographies in the Annual Report at appropriate intervals, rather than every year.

In conclusion, it is desired to stress the conscientious and enthusiastic work of the chairmen and members of the subcommittees to whose liberal contributions of time the progress made is due.

Transportation

ANNUAL REPORT OF THE COMMITTEE ON TRANSPORTATION*

YOUR Committee on Transportation submits a brief review of the recent developments of importance in the application of electricity to transportation.

Steam Railroad Electrification

Pennsylvania Railroad

The Pennsylvania Railroad has been actively continuing its electrification program. On June 29, 1930 electric operation was inaugurated between Philadelphia and Trenton, N. J., a distance of about thirty miles. On July 20th, electric operation was started between Philadelphia and Norristown, Pa., on the Schuylkill Division, seventeen miles. Fifty-nine multiple unit cars have been recently acquired. This installation completes the suburban electrification about Philadelphia. Distribution of power is at 11,000 volts, 25-cycle, single-phase. The equipment for suburban service is at present all motor cars, with multiple unit control.

The new suburban terminal at Broad Street was opened on September 28th. This is of necessity, entirely electrically operated, for the tracks are, like those of the passenger terminal at New York, under cover. The new suburban station at Thirtieth Street on the west bank of the Schuylkill River was also placed in service at this time. This will ultimately be an integral part of the Pennsylvania Terminal at West Philadelphia now under construction.

The Pennsylvania Railroad now has in electrified operation about Philadelphia, 132 miles of route and 437 miles of track; 345 multiple unit cars are in service.

Work is actively progressing in the New York Terminal zone preparatory to changing from the 600-volt third rail to 11,000-volt, single-phase trolley wire between Sunnyside Yard and Manhattan Transfer. This installation, which will among other things allow New Haven locomotives to enter the Manhattan Terminal, should be completed during the present year.

Construction is progressing between New Brunswick and Manhattan Transfer and will shortly be started between New Brunswick and Trenton, and between Wilmington and Washington.

Four types of locomotives are being developed for the complete electrification. Two passenger types, one freight and one yard switching. The light passenger type (designated as 0-1) is of 2-B-2 arrangement, and two of these units will be used on the heavy passenger trains. The heavy passenger type (P-5) is of the 2-C-2 arrangement. The freight type (L-6) is of the 1-D-1 arrangement. The passenger locomotives will use twin motors rated at 500 hp. per armature, or 1,000 hp. per axle. The freight locomotive will be equipped with four motors of single armature type, and will thus have a rated capacity of about 2,000 hp.

Long Island Railroad

The multiple unit suburban service of the Long Island portion of the Pennsylvania Railroad, operated by third rail distribution, is rapidly growing. Eighty-five multiple unit cars now being added to the equipment, bring the total number of cars to 825. To provide power for the increasing load, the Floral Park, substation is being remodeled and will be equipped with two rectifiers of 3,000-kw. capacity. Four new substations—Hempstead, Manhasset, Rockaway Park, and Goose Creek—are being built, in addition to four planned for installation next year. Each of the new substations will contain one 3,000-kw. mercury arc rectifier, except at Goose Creek where portable synchronous converter equipment will be installed. The rectifiers will be adapted for 60 or 25 cycle operation, an external reactance being added for the lower frequency.

*COMMITTEE ON TRANSPORTATION:

Sidney Withington, Chairman,

P. P. Ash,	K. T. Healy,	A. S. Richey,
R. Beeuwkes,	D. C. Jackson,	S. A. Spalding,
A. E. Bettis,	J. Murphy,	N. W. Storer,
J. V. B. Duer,	I. Ofverholm,	W. M. Vandersluis,
H. H. Field,	H. Parodi,	R. H. Wheeler,
I. W. Fisk,	W. B. Potter,	R. P. Winton,
W. A. Giger,	R. H. Price,	G. I. Wright.

elaware, Lackawanna & Western Railroad

The suburban electrification of the D. L. & W. R. R. as inaugurated between Hoboken and Montclair, N. J. n September 3, 1930, the service to South Orange, . J. September 22, 1930 and that to Morristown, . J. December 18th. The present electric installation as completed with the electric operation in January 931 to Gladstone and Dover, N. J. This electric peration comprises about sixty-eight route miles and ne hundred and fifty-eight miles of track; and includes 32 multiple unit cars. These cars operate in pairs, ne units consisting of one motor car and one trailer ach. Five substations, each containing mercury arc ctifiers, furnish the distribution power at 3,000 volts rect current. Two electric three-power locomotives il, storage battery, and trolley operated) have been cquired and are used for switching and transfer service etween Jersey City and Secaucus freight yards. The . L. & W. is the first heavy traction service in this ountry to utilize 3,000-volt direct current on motor ars, and the first to install exclusively mercury arc ctifiers.

ew York Central Railroad

The Cleveland Union Terminal electric operation as inaugurated June 28, 1930. This project comrises 17 miles of route and about 60 miles of track, etween Collinwood and Linndale, Ohio, and employs venty-two locomotives. These locomotives are 2-C - C-2, weighing about 204 tons, of which 150 tons on drivers. They are designed for a maximum peed of 70 mi. per hr. The locomotives are used interhangeably for switching or road service. Train eating boilers, oil-fired, are provided on the locomoves. The power distribution is by means of 3,000olt direct current, using a catenary system. This is pplied from two substations, one 3.5 miles west, and ne other 7.2 miles east, of the Union Station; each quipped with motor-generators, remotely controlled om the terminal building by a supervisory system of ne synchronous selective type. The installed capacity 9,000 kw and 6,000 kw. respectively.

The New York City electrification of the New York entral is progressing. The "West Side" tracks will e electrified by the middle of the current year as far outh as Seventy-second Street, the tracks north of hat point being on a viaduct, or on private right-of-ay. Forty-two freight locomotives have been purhased for this service. Distribution of power is by rect current at 650 volts using a third rail. South Seventy-second Street the tracks are on city streets, nd the operation will be accomplished by three-power il-electric-storage battery) locomotives, of which the ilroad has purchased thirty-five.

eading Railroad

The electrification of the Reading Railroad at hiladelphia is progressing, and operation should be arted about the middle of the current year. This project includes about 69 route miles and 161 miles of track; seventy multiple unit cars will be operated initially. The distribution system is at 11,000 volts, single-phase, 25 cycles.

Great Northern Railway

The Great Northern Railway has placed in service four new motor-generator locomotives with axle arrangement 1-C + C-1, essentially similar to those of that type already in operation. Each locomotive weighs 263 tons, of which 210 tons is on drivers. The distribution of power is at 11,000 volts, 25 cycles, single-phase.

Illinois Central

The Illinois Central Railroad placed in service in 1930, four 100-ton straight-electric locomotives for switching service, and also five 600-hp. oil-electric locomotives of the Diesel type. The motive power now in suburban service consists of 280 multiple unit cars, 140 of which are motor cars and 140 are trailers. In the freight switching service, there are now four straight-electric locomotives and six 600-hp. oil-electric. The power distribution is 1,500 volts, direct current. About 154 track miles are electrified.

New York, New Haven and Hartford Railroad

The final extension of the New York, Westchester and Boston Railway to Port Chester, N. Y. was completed late in 1929. The New York, Westchester and Boston—an integral part of the New Haven electric operation, now operates from Harlem River to Mount Vernon, N. Y., with branches to White Plains, N. Y. and to Port Chester, N. Y. The total New Haven a-c. electrified mileage is now about 577 track miles, over approximately 116 miles of route. The road operated, as of the end of 1930, 141 electric locomotives and 267 multiple-unit cars. The New Haven last year placed in service nine multiple-unit cars. During the current year there will be added to the equipment, ten 200-ton passenger locomotives and 33 multiple-unit cars. The power distribution of the New Haven is at 11,000 volts single-phase, 25 cycles, but the passenger motive power is designed to take power also from the New York Central third rail at 650 volts, direct current.

Substations for Electrified Railroads

The conversion of power for distribution on the Delaware, Lackawanna and Western electrification is, as previously noted, entirely by means of mercury arc rectifiers. This installation consists of 18 units in 5 substations with a total capacity of 40,000 kw. The rectifiers are also provided with a means of compounding, so that voltage can be maintained over a fairly wide load range at substations. Reference is made to the report of the Technical Committee on Automatic Stations covering this feature. Four of the substations are manually operated but are provided with many of the usual automatic protective features. One sub-

station is completely automatic. Remote and supervisory control are provided for the automatic substation and the tie stations.

In its electrification the Pennsylvania Railroad has continued with the 11,000-volt distribution system now in use on other parts of its system involving step-down transformer substations installed at intervals of 7 to 8 miles. The Reading electrification consists of the three-wire distribution system with 11,000 volts on the trolley and a feeder of 33,000 volts. Auto transformer stations are used at intervals, to transfer energy from the 33,000-volt feeder to the 11,000-volt trolley. Some of the substations of the Pennsylvania Railroad electrification are remotely controlled from adjacent signal towers, and those of the Reading are controlled by supervisory control so that the power director indirectly or directly has control of all circuit breakers within his jurisdiction.

The Cleveland Union Terminal Substations contain two and three 3,000-kw. motor-generator sets respectively, with complete automatic control. A synchronous selective supervisory control system with remote telemetering provides the dispatcher, located in the Terminal Building, with complete supervision and indication of the substation, feeders and tie station.

High-speed air circuit breakers have been employed in all substations of the d-c. systems mentioned above, and the Pennsylvania Railroad and Reading Railroad a-c. systems have employed high-speed a-c. breakers of the air and oil type. Reference is made to the report of the Committee on Protective Devices for data regarding the various types of high-speed circuit breakers available for a-c. and d-c. service.

Electric Locomotives

A novel development in the field of a-c. locomotive design has occurred abroad. In this design the low-voltage terminals of the transformer are permanently brought out, and all voltage control for the motors is by means of an oil-immersed tap changer and air switches from the high-voltage windings. The arrangement is a development of the growing use of the scheme of "tap-changing under load" and if it is found to be practicable under service conditions, should materially simplify the design of a-c locomotives.

A novel development in electric locomotive design has been accomplished in the new locomotive of the Illinois Central Railroad. This compensates the tendency of reduced weight upon the forward drivers at high drawbar loads, especially at starting, on account of the moment of the drawbar pull and rail reaction. The arrangement consists of shunts for weakening the field of the leading motor of each truck, which reduces the tractive effort of the leading motor and increases that of the rear, in proportion to the field strengths of the two motors. The forward drivers thus show less tendency to slip and the drawbar capacity is therefore increased.

There has been a number of notable improvements recently in the design and construction of the single-phase motor which have materially decreased its weight per horsepower and have improved efficiency and power factor. Attention is called to the report of the Committee on Electrical Machinery for descriptions of these developments.

Oil-Electric Locomotives

In addition to 35 oil-electric-storage battery locomotives acquired by the New York Central Railroad for the "West Side" operation in New York City, seven similar units have been placed in service in Chicago, and as above stated, two on the Delaware, Lackawanna & Western Railroad. The Canadian National last year acquired a Diesel locomotive, as have various industrial concerns.

A novel arrangement of Diesel locomotives has been developed, wherein the engineer's driving position is raised to a sort of mezzanine floor, so the engineer may look over the top of the train he is moving. In this design, controllers, air brake handles, etc., are provided at both sides of the cab so the driver may move from side to side as desired to observe signals from the switching crew.

Rail Cars

Fifty-six rail cars of gasoline and oil electric design were produced in this country during the past year. As an indication of the increasing use of this type of equipment in heavier service, the average power of these cars was about 450 hp. as compared with about 350 hp. the average in 1928.

Marine Transportation

A number of turbo-electric and Diesel-electric vessels of various types was produced in 1930. The *S. S. President Hoover* is the largest electrically driven liner produced thus far. The propelling equipment consists of two 14,000 hp. turbines with three-phase 10,100-kw. generators, and two 13,250-hp. synchronous induction motors. Auxiliary electric apparatus on steam and Diesel propelled craft has developed in a number of different directions, replacing steam auxiliaries. Attention is called to the report of the Technical Committee on Application of Electricity to Marine work.

Aviation

A number of electrical devices has added to the art of aviation during the past year. Among these is the "turn compensator," an electrically driven device to correct the error experienced in all types of "earth inductor" compasses when the direction of the ship is suddenly changed. This device may also be used as a "turn indicator" to show quickly and with reasonable accuracy the angular change in direction.

Recently developed engine-performance indicators, electrically operated, showing oil-pressure, oil-temperature, speed, etc., are of value especially on multiple-engine ships, by permitting remote indication.

In the field of illumination for aviation, wing-lights t into the leading edge of plane wings increase effi- ency by reducing non-productive air resistance. Air- ays are being illuminated by increasingly powerful d efficient beacons. The illumination of landing lds by means of flood lights and marking lights is eping pace with other developments.

Railroad Signaling

Centralized traffic control by means of coding stems is rapidly being extended on railroads. This ables a dispatcher or tower operator to remotely ntrol switches and signals over a large territory and us direct trains quickly and effectively without the cessity of train orders.

Urban Transportation

The chief developments in urban transportation are forts to obtain faster car acceleration, higher speeds, d better braking, to compete with increasingly fficult traffic conditions. The increased use of double- duction and worm gears has made the operation of gher speed motors practicable with marked decrease weight (especially in unsprung weight). Lower ors, with greater speed in loading and unloading, are atures of some of the new drives.

The modern trolley bus is being used for many rvices where street cars or gasoline buses were applied reviously. Economy of operation and low investment st insure a widespread use of trolley buses, especially here it is possible to utilize existing power plant, bstation, and power distribution facilities. In Chicago, r instance, over fifty-seven miles of line have been quipped for trolley bus operation, and seventy-five uses are in use.

The gas-electric coach, which has hitherto shown its ief advantages in congested urban traffic where equent and rapid acceleration is necessary, is invading e interurban field.

Attention is called to the expansion of the subway ileage in Philadelphia, New York, and Brooklyn. ans for a subway in Chicago have been approved.

Rail Fissure Detector

The Sperry device for detecting fissures in track rails s been operated intensively throughout the country with valuable results. Continued use of this device should materially reduce rail failures.

Welding

Electric welding is increasingly used not only in railroad shops (as in other industries), but for building up rails and "special work" at frogs, crossings, etc. Rail bonds for traction and signal purposes are in many instances welded to the head of the rails.

Vertical Transportation

The ever increasing height of buildings necessitates constantly increasing efficiency and speed of elevators. Speeds of 900 ft. per min. are now operated. A recent development to increase space efficiency in high buildings, is the operation of two or more elevators in a single shaft, so synchronized that one elevator may be started and run as "express" for a certain number of floors before the car next below it starts. Needless to say the operation is interlocked by means of limit switches and kindred devices to prevent the cars from coming together.

General

Attention is called to the development of various types of apparatus which apply to transportation as well as to other forms of utilization of electricity as described in various technical committee reports. Included in this category are turbo-generators and other power plant facilities, motors, circuit breakers, insulators, transformers, lightning arresters, cables, relays, substations, etc. Many of these types of apparatus are applicable to transportation, only by accomplishing some more or less important modifications, and the attention of various technical committees has been called to special modifications of this kind.

Attention is called to the work which is being carried on under the auspices of the American Standards Association on Definitions of Electrical Terms (C-42) for which the A. I. E. E. is sponsor. To Subcommittee No. 6 is assigned the field of "Horizontal Transportation." It is hoped that when this very important subject is complete, and published, general use will be made of the definitions and that some confusion which now exists will thus be avoided.

Protective Devices

ANNUAL REPORT OF COMMITTEE ON PROTECTIVE DEVICES*

THE work of the Committee on Protective Devices during the past year was accomplished largely through subcommittees, which are listed below with their chairmen:

Relays, W. W. Edson; Oil Circuit Breakers, Switches and Fuses, L. F. Hickernell; Lightning Arresters, H. K. Sels; Fault Current Limiting Devices, H. B. Wood; Joint Interconnection Subcommittee,† F. C. Hanker.

The activities of the Protective Devices Committee may be divided into the following three classes:

1. Preparation of standards
2. Review of research and development
3. Fostering the preparation and presentation of papers.

General

During the year the work of the committee in cooperation with the National Electric Light Association in the preparation of a supplement to the Relay Handbook was completed.

Revised standards for lightning arresters have been prepared and issued in report form by the Standards Committee.

Progress has been made in the preparation of standards for fuses and revised standards for disconnecting, horn gap and knife switches. It was hoped that the standard for fuses could be sent to the Standards Committee this year, but due to difficulties in obtaining complete agreement as to the subject matter of this standard there has been some delay. These standards should be forwarded to the Standards Committee in the latter part of 1931.

The committee has maintained close contact with research and development relating particularly to lightning protection, high-speed oil circuit breakers, and stability of operation, which greatly facilitated its work in fostering the preparation of suitable papers relating to these subjects.

*COMMITTEE ON PROTECTIVE DEVICES:

Raymond Bailey, Chairman,

J. E. Allen,	F. C. Hanker,	A. H. Schirmer,
A. C. Cummins,	E. A. Hester,	H. K. Sels,
H. W. Drake,	L. F. Hickernell,	H. P. Sleeper,
W. S. Edsall,	Dr. M. G. Lloyd,	E. R. Stauffacher,
W. W. Edson,	J. P. McKearin,	H. R. Summerhayes,
L. E. Frost,	H. A. McLaughlin,	E. M. Wood,
E. E. George,	A. M. Rossman,	H. B. Wood.
Herman Halperin,		

†This is a joint subcommittee of the committee on Power Generation, Power Transmission and Distribution and the Protective Devices Committee.

The work of the committee during the past year has emphasized more than ever the following points. First, the desirability of planning the presentation of papers sufficiently in advance so that they may be grouped for presentation in the most suitable manner. Second, the necessity, if maximum advantage is to be realized from Institute sessions, of having papers available for reading sufficient time in advance of meetings to permit of well considered discussion. The importance of this latter point is so great that every effort should be made to see that it is carried out effectively.

On account of the fact that in a number of cases other technical committees of the Institute have a very definite interest in the application or use of devices coming under the jurisdiction of the Protective Devices Committee, very close coordination of activities is required. This is particularly true in matters relating to interconnection and stability of operation handled at the present time by the joint subcommittee having representatives from the Power Generation and Power Transmission and Distribution Committees, in addition to the Protective Devices Committee. It may be that there will be sufficient important matters which affect a number of committees to warrant selecting some method of handling them that will permit of direct effective action without the complication and delays that are bound to happen in coordinating work with several large committees.

Relays

Report of Subcommittee

Further development of high-voltage transmission and interconnection with rather severe requirements as to stability and continuity of service, have focused attention on the necessity of rapid clearing with extreme precision, and the development of the art of relay protection has advanced as a consequence. Relays have been developed including directional, balanced, and differential relays capable of operating in one-sixtieth of a second.

These are being tried out in service and their operation is being watched with much interest. Apparently, additional work should be done to simplify these relays and their mechanical construction details, so as to insure among other things high-speed operation under all conditions, and to prevent shifting of the balance point. Also, further development will apparently have to be gone ahead with to eliminate certain difficul-

ties in the application of these relays to short line sections or to ground protection.

The most important work of the subcommittee for the year is the completion of the revised edition of the Relay Handbook, in cooperation with the corresponding committee of the N. E. L. A.

The following papers, prepared under the auspices of this subcommittee, have been presented before the Institute:

Relay Developments on Southern California Edison System, E. R. Stauffacher, Southern California Edison Company.

Operating Experience with Reactance Type Distance Relays, E. E. George, the Tennessee Electric Power Company.

Protection of Three-Winding Power Transformers, R. E. Cordray, General Electric Company.

Fundamental Basis of Distance Relaying, W. A. Lewis, Westinghouse Elec. & Mfg. Company.

Oil Circuit Breakers, Switches, and Fuses

Report of Subcommittee

A prominent feature of oil circuit breaker development is the number of large installations of metal-clad switchgear. Among these may be mentioned the installation of 33-kv. oil-filled gear on the system of the Public Service Company of Northern Illinois, the 13-kv. gum-filled gear at the Leaside Substation of the Hydro-Electric Power Commission, and air-filled gear on the system of the Jersey Central Power & Light Company.

Since last year's development of the deion circuit breaker, further results have followed the discovery of this method of arc extinction. With the addition of deion grids, ordinary oil circuit breakers have opened 3,500 amperes at 110,000 volts with 1.5 cycles of arcing; and 3,000 amperes at 200,000 volts with 3.5 cycles of arcing or less. Decreased arcing assures more satisfactory breaker performance, less deterioration of oil and contacts and lower maintenance. The stability of the whole power system is improved, since short circuits are more likely to be cleared before they can affect synchronous machines.

The deion oil-less breaker in the meanwhile has been developed for a greater range of ratings. At one extreme is a one million kva. 23 kv. circuit breaker which has undergone interrupting capacity tests including some shots as high as 800,000 kva. (It will be recalled that among last year's achievements were reported successful interruptions of short circuits in the order of 60,000 kva.) On the other extreme is the breaker (using 2.5-inch plates) which repeatedly interrupted 10,000 amperes at 600 volts alternating current. This small deion breaker shows great promise in a wide field of the moderate and smaller powers; such, perhaps, as industrial service.

Efforts to improve rating standards for oil circuit breakers continue.

Announcements by the manufacturers indicate healthy activity in the development of new forms of circuit interrupters, such as the oil-blast oil-circuit breakers, multiple break and others.

The following papers, prepared under the auspices of this subcommittee, have been presented before the Institute:

The Mechanical Performance of Oil Circuit Breakers, A. C. Schwager, Pacific Electric Mfg. Co.

Outdoor Switching Equipment at Northwest Station, W. F. Sims and C. G. Axell, Commonwealth Edison Co.

Magnitudes and Rates of Rise of Circuit Breaker Recovery Voltages, R. H. Park and W. F. Skeats, General Electric Co.

Trend in Development of Modern Circuit Interrupters, J. B. MacNeill, Westinghouse Elec. & Mfg. Co.

Oil Circuit Breaker Tests—Philo 1930; Aims, Set-Up and Results from a System and Operating Point of View, Philip Sporn and H. P. St. Clair, American Gas & Elec. Co.

The Oil-Blast Circuit Breaker, D. C. Prince and W. F. Skeats, General Electric Co.

Field Tests on Standard and Oil-Blast Explosion Chamber Oil Circuit Breakers, R. M. Spurck and H. E. Strang, General Electric Company.

Lightning Arresters

Report of Subcommittee

The Subcommittee is advised that studies of lightning and the effects of lightning were continued throughout the year by means of field investigations on transmission systems in several widely separated localities. The knowledge of the character and behavior of high-voltage surges originating from lightning on transmission lines was extended by the use of cathode-ray oscillographs at field stations located in Arkansas, Illinois, Michigan, New Jersey, Ohio, Pennsylvania, and West Virginia. In two cases, Michigan and New Jersey, the behavior of waves on transmission lines was studied in detail by the use of both portable cathode-ray oscillographs and impulse generators. Practically a continuous investigation was maintained also of the performance of lightning arresters and many other associated phases of the lightning protection problem. About 3,000 oscillograms were taken which have already proved valuable in the study of problems related to lightning protection.

Better coordination of records in the 1930 lightning investigations has indicated the growing importance of direct strokes. Records obtained on high-voltage lines tend to confirm the thought that overvoltage due to direct strokes are more important than those due to the induced effect from lightning strokes primarily on account of their greater magnitude.

Impulse tests made in the field tend to confirm the conclusion that best protection with lightning arresters is obtained when the arrester is located close to the equipment to be protected and the leads as short as possible with low ground resistance. If the arrester cannot be located close to the equipment and at the

same time retain short leads, keeping the leads short appears to be the more important. Also, the arrester and equipment should be connected to the same ground but if this is not convenient, more attention must be given to the arrester ground to be sure that its resistance is as low as possible.

The highest voltage lightning arresters ever built were recently installed by the Hydro-Electric Power Commission of Ontario. Under emergency conditions of generator overspeed and abnormal line voltage, they will not be damaged by voltages as high as 268,400 volts. Normally, four of the twenty-two arrester units in each phase leg are short circuited by a high speed switch which opens automatically in less than half a second when waterwheel overspeed and overvoltage occurs. This is also the largest arrester installation for voltages over 200,000. One three-phase arrester is installed for the protection of each of four banks of transformers.

The commercial development of the porous block autovalve arrester has made available a new arrester which is considerably smaller and has much better performance characteristics than the earlier autovalve. The arrester is constructed in fewer porcelain-cased units with a totally enclosed gap structure which in the lower voltage sizes results in the complete arrester being housed in a single casing or two casings with gaps and elements separate. The protective action of the arrester is similar to the old one but it has practically no time lag in its operation and a low ratio of discharge voltage to normal voltage. A small and compact form of line arrester has been developed which can be applied to prevent the flashover of insulator strings. A number of installations of these line arresters has been under observation for the past two years in order to gather data on the effectiveness of such protection for transmission line insulators.

With the commercial development of thyrite, a new form of lightning arrester became available. The arrester is constructed in the form of self-contained units, it only being necessary for any application to mount an appropriate number of units one upon another. A gap structure has been provided in each unit so constructed that substantially no time lag occurs in the operation of the gap. This arrangement, coupled with the characteristics of the material, insures an arrester which has practically no time lag in its operation. A number of installations of these arresters has been made, the highest voltage arrester in service being of 230 kv. rating. Another form of thyrite arrester was developed which is incorporated in a string of suspension insulators and used to prevent the flashover of the insulator string for all but the most severe conditions.

A new protective device operating on a deion principle in a small bore tube for use in the prevention of insulator flashover by lightning has been developed in certain voltage ratings.

The revision of the proposed Standards for Lightning Arresters for alternating-current power circuits was completed and accepted by the Committee on Protective Devices for printing in report form. The subcommittee hopes that there will be widespread use of these standards in order that they may be put in final shape for adoption by the Institute. It is expected that development in the art of protection from lightning will probably make it necessary to revise these standards from time to time as additional technical information becomes available.

The work of the subcommittee indicates that the following matters should receive considerable attention in the future: (1) the determination of more representative test surges, (2) the development of tests to determine operating condition of arresters in service, (3) investigation of present operating practise on transmission and distribution systems relative to arrester installation, operation and performance as affecting suitable standards, and (4) the coordination of line and station type arrester application in the field with the activities of other committees interested in the grading of system insulation.

The following papers, prepared under the auspices of this subcommittee, have been presented before the Institute:

An Experimental Lightning Protector for Insulators, J. J. Torok, Westinghouse Elec. & Mfg. Co.

Field Tests on Thyrite Lightning Arresters Using Artificial Lightning of 1,500,000 Volts, K. B. McEachron and E. J. Wade, General Electric Company.

Fault Current Limiting Devices

Report of Subcommittee

The reactor installations made during the year are characterized by high electrical ratings and greater physical size, particularly in bus-sectionalizing applications which seem to be on the increase.

Among the largest ever built in physical size is an application of 4,000-kva., 161-kv. bus sectionalizing reactors giving 10 per cent reactive drop when 120,000 kva. is transferred across the reactor.

Another outstanding installation from the standpoint of physical size consists of three 5,400-kva. oil-immersed reactors on the 110-kv. system of the Pacific Gas & Electric Co.

Noteworthy from the standpoint of electrical rating are eighteen bus-sectionalizing reactors rated 7,340 kva. giving a 16½ per cent reactive drop in a 133,000-kva., 27,600-volt circuit now on order.

Current-limiting reactors of the dry type installed in metal housings and rated 833 kva., 693 volts, 1,200 amperes, 60 cycles, were used to sectionalize a 24,000-volt bus. They introduce 5 per cent reactive drop between the sections when 50,000 kva. are being transferred. The housings are supported on insulators and are connected to a ground bus.

Bus-sectionalizing reactors were in some instances provided with disconnecting devices which automatically break the circuit when the reactor is removed from its operating location.

Representative opinion has been secured on the

desirability of including in the new A. I. E. E. Standard for Fault Current Limiting Devices the material on reactors now in A. I. E. E. Standards No. 13 and also information on grounding transformers, generator neutral reactors, and Petersen coils. As yet no definite decision has been reached.

Interconnections

Report of Joint Subcommittee

The work of the Joint Interconnections Subcommittee has related almost entirely to the preparation of papers. A comprehensive paper on *Present Day Practise in Grounding of System Neutrals* was prepared by the subcommittee and presented at the Pittsburgh District Meeting.

A paper entitled *Impulse Test on Substations*, by Messrs. Brookes, Southgate, Roman, and Whitehead, was presented at the Winter Convention.

The following papers were presented at the Pittsburgh Meeting:

Committee Report on Present Day Grounding Practises, C. A. Powel, Chairman.

Reactance of Transmission Lines with Ground Return, J. E. Clem, General Electric Company.

Power System Voltages and Currents Under Fault Conditions, R. D. Evans and S. H. Wright, Westinghouse Elec. & Mfg. Company.

Simultaneous Faults and Six-Phase Transmission, Edith Clarke, General Electric Company.

Power System Voltages and Currents Under Fault Conditions, R. D. Evans and S. H. Wright, Westinghouse Elec. & Mfg. Co.

Series Resistance Method of Increasing Transient Stability Limit, R. C. Bergvall, Westinghouse Elec. & Mfg. Co.

Research

ANNUAL REPORT OF COMMITTEE ON RESEARCH*

DURING the year the Committee members have reviewed twenty-six papers and recommendations have been made to Headquarters for their disposition. Each paper has been reviewed by three or more members and outside experts. The Committee held one session at the Winter Convention at which eight of the approved papers were presented. Additional papers, obtained through the Committee on Research, are scheduled for the Summer Convention and several papers made available for district meetings. All business was carried on through correspondence as the only Committee meeting scheduled, at the Winter Convention, had to be abandoned because of conflicts.

The following topics are of sufficient importance to be called to the attention of the electrical engineering profession. The subjects reported have all been suggested by the Committee members, special assistance having been given by Messrs. W. G. Cady, V. Karapetoff, H. H. Race, D. W. Roper, T. Spooner, and J. B. Whitehead.

Physics

In the field of physics there has been a number of theoretical and experimental accomplishments of some interest during the past year.

The knowledge of cosmic rays has been advanced somewhat with two schools of thought: certain investigators, as a result of certain experimental evidence, are convinced that cosmic rays are actually high velocity particles. However, Dr. Millikan, from intensity measurement of the cosmic rays in northern latitudes, feels quite certain that they are actually rays, since they are not affected by the earth's magnetic field. Dr. Millikan concludes that the cosmic rays have their origin not in the stars, but in interstellar space and that they are due to the building up of the commoner heavy elements from hydrogen, it being thoroughly established by spectroscopy that hydrogen is widely distributed through space. Several of the more common elements and also helium exists in interstellar space.

After seven years of intensive work, Dr. Paul Heyl of the Bureau of Standards has remeasured the constant of gravitation, or as the newspapers would put it, the weight of the earth. This figure is 6.670×10^{-8} c. g. s. units.

Eddington has developed a theory which makes possible the calculation of the ratio of masses of an electron and proton as well as the sizes of the electron and of the universe.

The generation of very short radio waves is possible by a number of means, among them the Barkhausen tube. This tube is a three electrode tube with suitable voltages applied to the grid and plate and provided with parallel Lecher wires. The frequency is dependent on the speed of the electrons as affected by the voltages

*COMMITTEE ON RESEARCH:

L. W. Chubb, Chairman,

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and spacing of the electrodes and is independent of the external characteristics. Shuster has applied quantum mechanics to the problem of the Barkhausen tube and has calculated correctly the observed frequencies.

As a result of the work of Grondahl it has been known for some years that copper oxide on copper had a photoelectric effect, making possible the generation of electric energy from sunlight. Dr. B. Lange of the Kaiser Wilhelm Institute for silicate investigation has obtained some interesting results with the copper oxide cell. According to newspaper reports he has, with the use of silver selenide, obtained similar results, but of one hundred or more times as much magnitude. However, for the generation of power from sunlight, the development is very far from being commercial owing to the high cost and low output.

Medicine and Physiology

In the realm of medicine and physiology there has been a number of developments of interest to the electrical engineer. The recent paper on "Experiments on High Voltage Tubes," by Tuve, Hafstad, and Dahl of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, describes an X-ray tube, the voltage of which can be as high as 2,000 kilovolts. At 1,300 kilovolts the absorption coefficient, after filtering through one inch of lead is the same as that for the gamma rays from radium in equilibrium measured under the same conditions with the same instrument. This result has been attained by the so-called heat working of the pyrex glass. This high voltage tube should serve as a new tool to the medical profession.

For the treatment of cancer there has been developed by Dr. W. D. Coolidge a 900,000-volt X-ray tube to be installed in the New York Memorial Hospital.

It is well known that fever assists in destroying certain disease germs. It is possible, by the use of high frequency electrostatic fields, to produce artificial fever, thus assisting nature. Considerable success has been obtained by this method during the past year.

Dr. George Sperti of the University of Cincinnati has succeeded in using selected regions in the ultraviolet spectrum for the irradiation of foods; for example, he has been able to create Vitamin D in milk without spoiling the taste.

Dr. H. C. Rentschler has developed a method for measuring ultraviolet radiation by the use of a suitably designed photocell and a condenser. The condenser is charged slowly through the photocell and discharges through a counter at a rate dependent upon the ultraviolet radiation received by the photocell.

Dielectrics

Considerable progress has been made in insulation and dielectric research during the past year. Much work is being done to improve the processing in the manufacture of high-voltage cable insulation and also to detect a faulty impregnated cable before it goes into service. At Johns Hopkins University the value of thorough drying by the use of vacuum and air pressure during impregnation and the use of gas free oils have been studied further. To detect poor insulation, research workers of the University of Illinois are measuring high frequency discharges which constitute internal ionization.

Studies on the oils themselves are under way at the Detroit Edison Company, Cornell University, and the Brooklyn Edison Company, with special emphasis on the life characteristics and products of such oils under electrical stress, particularly ionic and electronic bombardment. At the Detroit Edison Company, it has been found that by bombardment of the oil vapors in a vacuum, the composition of the gas produced varies from one hydrocarbon to another and is quite complex, but consists roughly of 50 per cent hydrogen and 50 per cent unsaturated hydrocarbons. Liquids and wax-like solids are also produced. The solid formed is a duplicate of the compound "X" found in cables which have been in service. The formation of this substance in cables indicates internal corona. Five normal paraffin hydrocarbons of simple chemical structure and of very high purity have been prepared at the Bureau of Standards and studies are being made of their electrical characteristics.

Further studies have been made of polar compounds in liquid dielectrics. The frequency-temperature-loss characteristics have been studied in a number of laboratories with most interesting results. In addition, the polar characteristics of certain commercial insulating liquids are being studied, particularly the change and polar characteristics during service. These fundamental studies should aid in a choice of better insulating oils.

At Johns Hopkins University correlation between d-c. absorption and a-c. dielectric loss has been verified for several oils, dried paper and impregnated paper consisting of the materials previously studied alone. The relatively high d-c. conductivity of oil obtained up to about one second after electrification was found to account for the a-c. losses. The electrical characteristics of the separate and combined materials of impregnated paper insulation have been studied. This is a very important step in the fundamental side of dielectric research.

Another field of investigation which is just getting under way is the use of X-rays to study the molecular structure of dielectrics. The work of Dr. Zwicky at the California Institute of Technology on mosaics and on sodium chloride crystals, and the work in Chicago by Dr. Bennett on the effect of an electric field on the arrangement of paraffin crystals are worthy of notice.

There have been numerous important and interesting engineering developments during the past year.

Lightning Research

As the result of the investigations of natural and artificial lightning carried on at a number of field stations in various parts of the country, it has been pretty definitely established by the use of the cathode ray oscillograph that most outages and damage to transmission lines are the result of direct strokes rather than induced lightning. Two records during 1930 were obtained of crest values of 4,500 and 5,000 kv. The latter value was recorded at a distance of several miles from the stroke. At the place of flashover it is estimated that the potential was at least 10,000 kv. It has been concluded that a lightning stroke to a ground wire, if flashover does not take place, does not result in a surge over the line. By using proper precautions it is believed, as a result of these lightning investigations, that it will be possible to build transmission lines which will be practically immune from lightning.

There have been developed and placed on the market during the year, two new types of lightning arresters, namely the thyrite arrester by the General Electric Company and the new porous block autovalve arrester by the Westinghouse Elec. & Mfg. Co. These arresters have characteristics which are considerably superior to their predecessors.

The commercial development and application of new types of discharge tubes have been very active recently. It seems evident that these devices are going to occupy a very large place in the control and conversion of power.

Radio

In connection with radio there have been developed and put into commercial operation, 200 kw. transmitting tubes for broadcast stations.

Mercury-glass three-phase rectifiers have been developed to supply plate current for these high power radio tubes. These rectifiers are rated at 10,000 volts and 30 amperes. Additional grid-controlled gaseous discharge tubes, namely, the Westinghouse grid glow tubes and the General Electric thyratrons which are similar in their characteristics, have been developed during the year, the larger sizes being able to handle 75 amperes at voltages up to 1,000 or even 2,000. A grid energy of ½ watt or less is required.

Many new applications for grid glow tubes have been made recently. Among them is the theater light dimmer system which is controlled by very small rheostats which regulate the voltage applied to the grids of the tubes. These tubes supply rectified alternating current to choke coils which are saturated by the pulsating current, thus changing the inductance and controlling the lights. The small control wires can be led to any desired location, thus concentrating the control and simplifying the operation of the system. There are no moving parts and contacts, except for the small control rheostats. A very great advantage of this type of control is that the whole lighting program for the evening may be preset.

Miscellaneous

A new stroboscope called a stroboglow has been developed, which illuminates a moving object for a period of only 3/10 of a microsecond or less. This interval is so short that an object moving at seven miles a minute appears to be perfectly stationary with no appreciable blur. No moving parts are necessary and no connection between the stroboglow and the moving object is required. The instrument is calibrated for frequency and may be used to determine the speed of rotation of the illuminated object.

A very small tube rectifier has been developed, rated at 3/10 of an ampere and 5,000 volts. This rectifier is 4½ in. long and 1¼ in. in diameter. It can be operated satisfactorily up to 10,000 volts and under special conditions, has been carried as high as 30,000 volts. These tubes are particularly suited for airplane radio transmitters.

A new oscilloscope with a linear time axis has been developed which employs a new type of cathode ray tube for its essential element. This oscilloscope has the advantage over previous types in that it has a larger field and the illumination is very much greater, making it possible to observe recurrent phenomena in a well lighted room. Non-recurrent phenomena lasting for a few microseconds, can also be observed readily for qualitative results. For recurrent phenomena the cathode beam may be synchronized so that the image appears stationary.

An automatic traffic control system has been developed and put into experimental use on main highways, using a beam of light crossing the side streets. When a car or other vehicle approaches the main highway on the side street, the beam is intercepted, thus causing a photocell to act giving the minor street the green light.

There has been developed in Germany another application of the light sensitive devices for the purpose of stopping railroad trains. Light from the headlight of the locomotive is reflected from a mirror on the semaphore and returns to photocells on the locomotive, which when illuminated operate the automatic stop mechanism.

There has recently come into general use in this country the electric photo-flash lamp which was developed in Germany and is used as a substitute for flash-light powder. The bulb contains a quantity of aluminum foil in an atmosphere of oxygen. A small filament, when heated electrically, causes the aluminum foil and oxygen to combine with an intense illumination. The elimination of noise and smoke is greatly appreciated by the average audience.

Studies and applications of piezo electric quartz crystals have been continued at Wesleyan University. By means of the cathode ray oscillograph, the rate of

dying away of the oscillations of these crystal resonators has been studied. It has been found that a 600-kilocycle crystal started vibrating and left to itself, makes 60,000 vibrations before its amplitude falls to 1 per cent of its initial value. Various types of mountings for the crystals as well as the effect of the shape, cut and material of the crystal itself are being studied. A determination of the viscosity of quartz as a function of frequency is yielded by the above measurements. The coefficient of viscosity or quartz is approximately five at 600 kilocycles as contrasted with 500 for aluminum at 60 kilocycles and with values of the order of 10^8 ordinarily quoted for the low-frequency viscosities of metals.

A very accurate clock developed by the Bell Telephone Laboratories was exhibited at Cleveland last December, which is unique in that it is controlled electrically by a spherical quartz crystal.

The Stevens Institute of Technology reports the development of a clock which is automatically corrected by the standard radio time signals.

The limitations and advantages of commutation and current collection in hydrogen have been determined by laboratory and commercial experiments. In general, in the hydrogen atmosphere there results a lower contact drop. Satisfactory operation and long life are obtained if sparking is kept low. If appreciable sparking is present the humidity must be kept low.

The application of the helical groove to slip rings and commutators has been developed and applied commercially. Under severe conditions of commutation and current collection this apparently reduces brush wear and improves the electrical operation by reducing the formation of local hot spots; also better distribution of current between parallel brushes results.

A sample of commercial hipernik (a 50 per cent nickel-iron alloy) has been obtained having a maximum permeability of 167,000. Test samples from other castings have given as high as 13,000 for initial permeability and upwards of 400,000 for maximum.

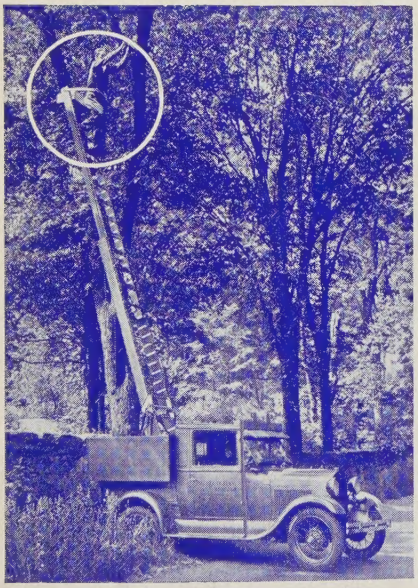
Work during the past year on the fundamental nature of arcs and their extinction has given a greater insight into the problem of circuit interruption and is having a very definite effect on the design of circuit breakers.

There has been developed a non-destructive magnetic weld test meter for use with butt welds, which shows some promise commercially. For a given type of weld and a definite kind of steel, comparative results on welds are quite reliable.

At the Naval Research Laboratories interesting work has been done using the radiographic method for detecting imperfections in large steel forgings. Ordinary X-rays can penetrate only three or four inches of steel, but by the use of radium it has been possible to obtain photographs through twelve inches of steel. The radium has the advantage that it can readily be transported to the piece to be inspected and requires no complicated auxiliary equipment. If thick pieces of steel are to be photographed, however, either a long time must be used or a considerable quantity of radium or radium emanation must be available.

MURRAY CROWSNEST

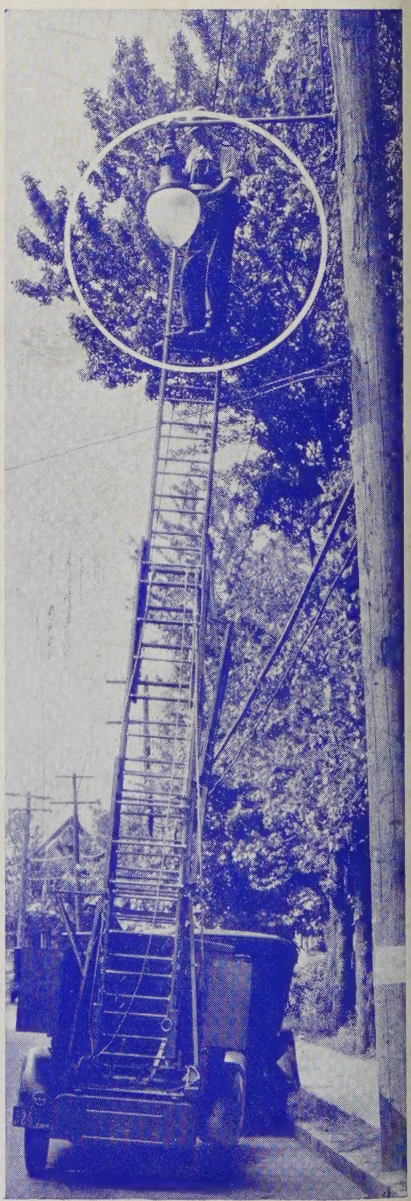
Safe and Economical



The Murray Crowsnest is economical and reliable for lamp service and construction work, for emergency calls, for servicing traffic lights, for line work and tree trimming, for repairing trolley wires and for work on telephone and telegraph wires.

These illustrations show "every-day" applications of the Murray Crowsnest. Its operation is rapid, it is safe, it is inexpensive to buy and maintenance is a minimum. It may be mounted on a light truck such as a Ford or Chevrolet.

For economy and safety, for adaptability to a great variety of work and for speedy operation, the Murray Crowsnest has no equal.



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